No. 12885

United States
Court of Appeals
for the Ninth Circuit.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION and AMERICAN AIR LINES, INC.,

Appellants,

vs.

MAURICE A. GARBELL, INC., and GARBELL RESEARCH FOUNDATION,

Appellees.

Transcript of Record

Volume III
Book of Exhibits
(Pages 605 to 834)

Appeal from the United States District Court, Southern District of California, Central Division.

Phillips & Van Orden Co., 870 Brannan Street, San Francisco, Calif.

PLAINTIFF'S EXHIBIT NO. 2
Admitted November 21, 1950.

May 18, 1948. M. A. GARBELL 2,441,758

FLUID-FOIL LIFTING SURFACE

Filed July 16, 1946 3 Sheets-Sheet 1

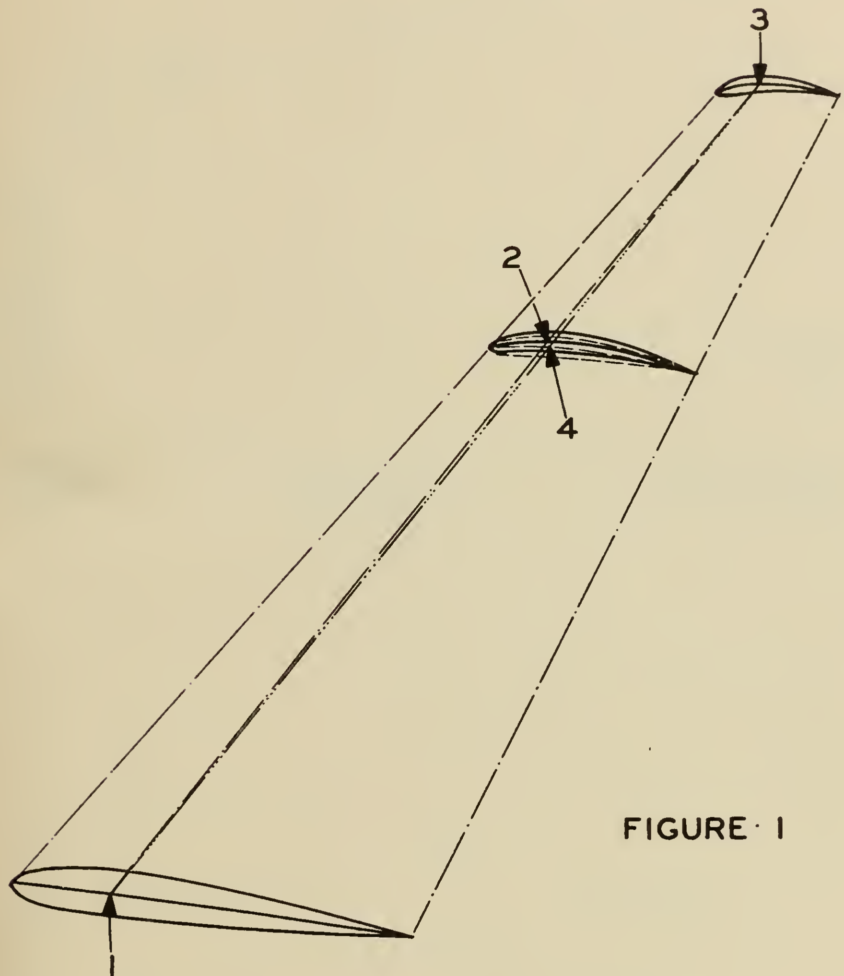

FIGURE 1

Maurice A. Garbell INVENTOR.

BY Naylor and Lassagne
ATTORNEYS

FLUID-FOIL LIFTING SURFACE

Filed July 16, 1946 3 Sheets-Sheet 2

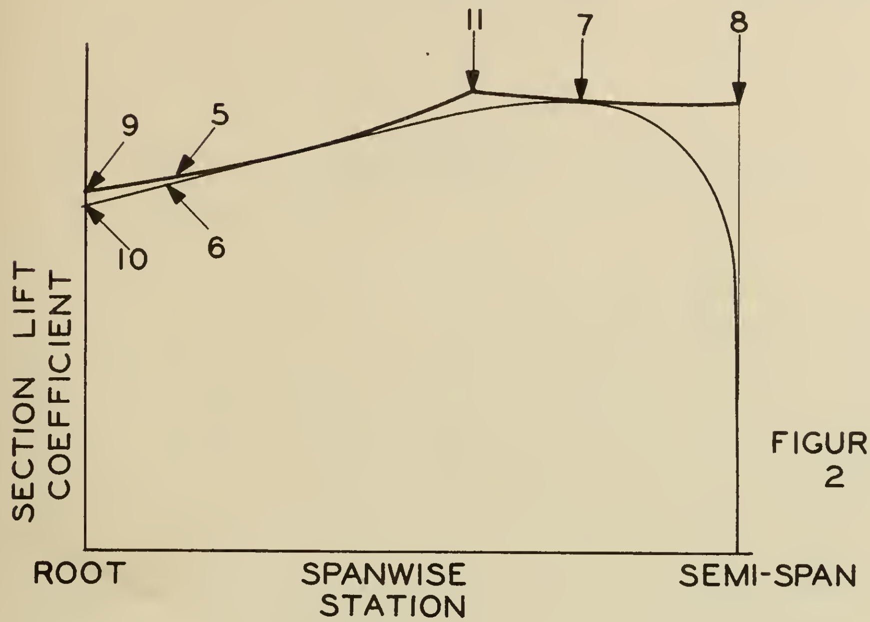

FIGURE 2

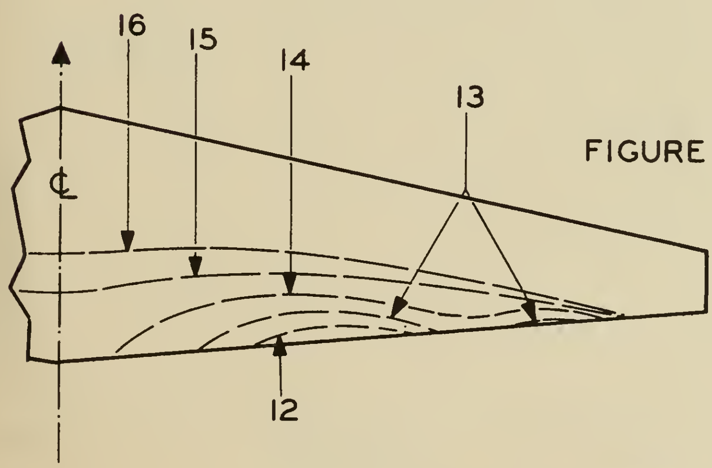

FIGURE 3

Maurice A. Garbell INVENTOR.

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May 18, 1948. | M. A. GARBELL | 2,441,758

FLUID-FOIL LIFTING SURFACE

Filed July 16, 1946 | 3 Sheets-Sheet 3

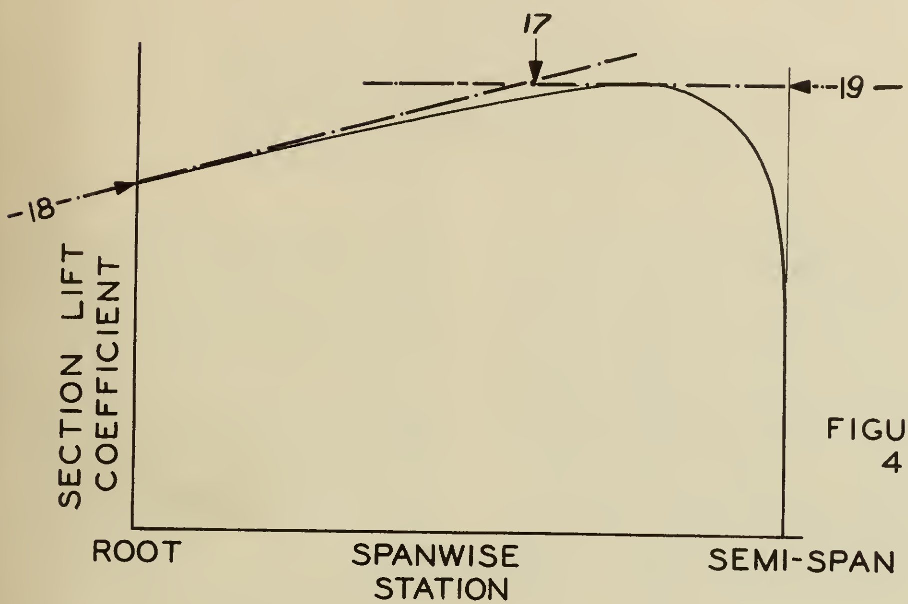

FIGURE 4

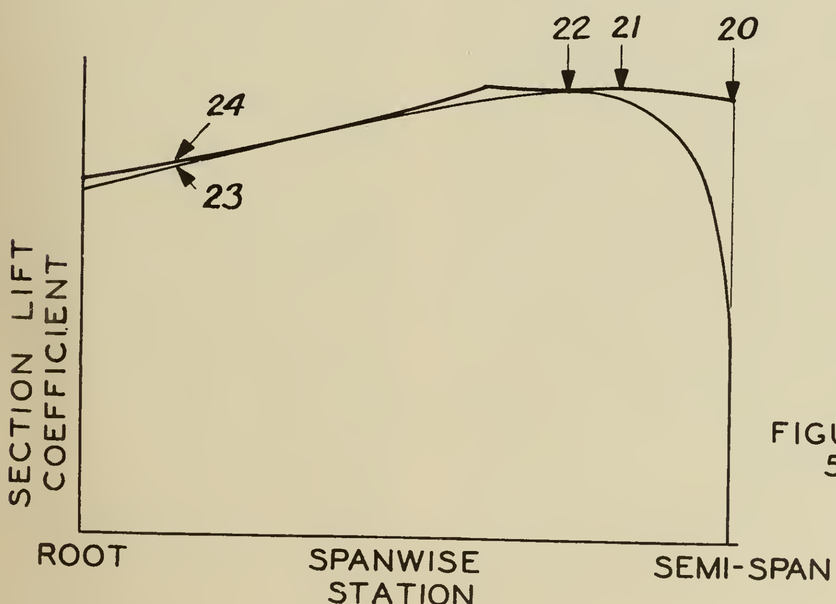

FIGURE 5

Maurice A. Garbell INVENTOR.

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Patented May 18, 1948 2,441,758

UNITED STATES PATENT OFFICE

2,441,758

FLUID-FOIL LIFTING SURFACE

Maurice Adolph Garbell, San Francisco, Calif., assignor to Maurice A. Garbell, Inc., San Francisco, Calif., a corporation of California

Application July 16, 1946, Serial No. 683,815

15 Claims. (Cl. 244—35)

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This invention relates to the design and con-truction of surfaces to be driven through a fluid, ntended to produce a useful force component erpendicular to the relative velocity of the fluid vith respect to the surface, known in the art as lift force," "side force," etc., and referred to ereinafter as "lift."

In particular this invention relates to the de-ign and construction of surfaces to be driven hrough the air, intended to produce an aerody-amic lift force perpendicular to the relative vind velocity with respect to the said surface, vhile minimizing the aerodynamic drag force arallel to the relative wind. In the art such urfaces are known as "wings," "fins," "blades," tc., and will be referred to hereinafter as "lift-ng surfaces." The closed curves resulting from ntersections of the lifting surfaces with vertical lanes parallel to the relative wind will be re-erred to hereinafter as "fluid-foil sections." The body to which the lifting surface is fastened vill be referred to hereinafter as the "craft."

Figure 1 illustrates the preferred embodiment f this invention comprising a lifting surface de-igned and constructed according to the method utlined in the subject specification.

Figure 2 illustrates the spanwise distribution f actually prevailing section lift coefficients and he spanwise distribution of maximum attainable ection lift coefficients on a typical lifting sur-ace designed and constructed according to the ubject method of this invention.

Figure 3 illustrates the typical inception and rowth of the stall of a lifting surface designed nd constructed according to the subject method f this invention.

Figure 4 illustrates the procedure employed in he finding of the optimum spanwise location of he third controlled fluid-foil section in a lifting urface designed and constructed according to he subject method of this invention.

Figure 5 illustrates the spanwise distribution f actually prevailing section lift coefficients and he spanwise distribution of maximum attainable ection lift coefficients on a typical lifting sur-ace designed and constructed according to the ubject method of this invention, the tip section f said lifting surface having a thickness ratio maller than the optimum thickness ratio for bsolutely maximum attainable section lift co-fficient for the series of fluid-foils employed in he lifting surface.

The general object of this invention is the at-ainment of good stalling characteristics of lift-ng surfaces, said good stalling characteristics eing achieved by the employment of three or

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more controlled fluid-foil sections 1, 2, and 3, selected according to the method explained in the subject specification of this invention, wherein section 2, representing the additional controlled sections interjacent between the root and the tip of the lifting surface, is at variance with the section 4 obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil sections located at the root and the tip of the lifting surface.

Another object of this invention is the elimination of the violent rolling moments ordinarily produced by the unavoidable asymmetry of the stalling process, because the aforementioned method of fluid-foil selection suppresses the stall inception at the tip of the lifting surface and induces stall inception at a more inwardly located panel of the lifting surface, thus reducing the rolling moments acting on the craft for a given asymmetry of lift forces on the two stalled lifting surfaces.

Another object of this invention is the maintenance of adequate lateral-control effectiveness, together with the elimination of violent unstable control forces acting on control surfaces and devices attached to the trailing edge of the tip panel, during the critical stall-inception stage of the lifting surface, because the aforementioned method of fluid-foil selection induces stall inception at a more inwardly located panel of the lifting surface, so that the fluid flow over the tip panel and hence over the said control surfaces and devices remains smooth, thus maintaining effective lateral control as well as stable and smoothly varying control forces throughout the stall of the lifting surface.

Another object of this invention, through the employment of the aforementioned method of fluid-foil selection, is to reduce both the parasite drag and the induced drag of the unstalled lifting surface, and to shift the spanwise location of the "center of drag forces" of the stalled lifting surface inwardly so that the drag moment of the stalled lifting surface with respect to a vertical axis at or near the root is reduced to a value smaller than that of a lifting surface having a stall inception near the tip thereby reducing to a minimum the power required to maintain the rotation of partially or totally stalled lifting surfaces of the "rotating-wing" or "rotating-blade" type.

Additional objects of this invention will appear hereinafter.

In the art the achievement of the objects of this invention is recognized as one of the great steps in advancing safety and efficiency in aircraft design. According to accident statistics of the Civil Aeronautics Boards and other aeronautical agencies most flying accidents, especially those accidents occurring while flying in proximity of the ground, during take-off, and when landing, are caused by the stall of the lifting surface, the severity of such accidents being attributable not so much to the loss of lift directly, as indirectly to the adverse longitudinal and lateral stability characteristics, to the loss of control effectiveness, and to the violent unstable control forces produced by the stall inception near the tip of the lifting surface.

An investigation of the fundamental reasons for unsatisfactory and hazardous stalling characteristics reveals that high plan-form taper and sweep-back of the lifting surface create three principal unfavorable effects resulting in a stall inception near the tip of the lifting surface: (1) a reduction of the scale factor known in the art as "Reynolds number" in direct proportion to the decrease of chord length from the root to the tip; according to well-known experimental evidence the maximum section lift coefficient attainable with a given fluid-foil section placed in the tip panel of the lifting surface is smaller than the maximum section lift coefficient that the same section would be capable of attaining were it placed in the root panel where the chord length and hence the Reynolds number are greater; (2) a deviation from the ideal "elliptical span-load distribution" tending to increase the lift coefficients prevailing over the tip sections and to reduce the lift coefficients prevailing over the root sections at any given total lift coefficient of the lifting surface; (3) an outwardly directed spanwise fluid cross-flow, especially on the suction side of the lifting surface; this cross-flow at high lift coefficients of the lifting surface in an additional incentive for fluid-flow separation and stall near the tip of the lifting surface.

In the art, prior to this invention, it was customarily sought to counteract the aforementioned factors that contribute to the stall inception in the tip panel by resorting to the following measures: (*a*) effective washout, that is, washout of the zero-lift line of the fluid-foil section at the tip with respect to the zero-lift line of the root section, thus reducing the effective angle of attrack of the tip section below the effective angle of attack of the root section; (*b*) the employment of a fluid-foil section with a more highly cambered mean line at the tip of the lifting surface than at the root, in order to enable the tip section to attain higher maximum section lift coefficients.

These measures, however, have not been entirely successful in suppressing the stall inception near the tip of the lifting surface; the spanwise distribution of the actually prevailing section lift coefficients reaches a peak near the tip and therefore inevitably intersects the nearly linear spanwise distribution of maximum attainable section lift coefficients in this most critical portion of the lifting surface.

As a rule the resulting stall patterns remain unsatisfactory for all but the lowest of plan-form taper ratios, and may become dangerously critical for plan-form taper ratios in excess of 3:1 and for any highly swept-back lifting surfaces. The stall inception in the vicinity of the tip of the lifting surface and a comparatively slow inboardward progression of the stall with any further increase of the angle of attack of the lifting surface results in the most vicious type of tip stall, with little or no stall warning, violent rolling moments, loss of lateral control, violent unstable control forces, and unstable nose-up pitching moments throughout the stall.

It was therefore customary in the art, prior to this invention, to employ as much washout and camber variations as was deemed permissible, and to transfer the further responsibility for the avoidance of the admittedly unsatisfactory stalling characteristics to the care of the pilots, or to warning signals actuated by the stalled fluid flow, or to a limitation of the elevator control travel to prevent the attainment of the high angles of attack at which stall occurs.

Techniques utilizing three controlled fluid-foil sections, in which the section at the semi-span center has either greater or smaller mean-line camber than the sections at the root and tip, have also failed to offer any substantial improvement of the dangerous tip-stall characteristics of highly tapered and/or swept-back lifting surfaces.

A preferred embodiment of this invention is described in the following specification; the broad scope of the invention is expressed in the claims concluding the instant application.

The invention consists of novel methods and combinations of methods described hereinafter, all of which contribute to produce a safe and efficient lifting surface.

Figure 1 illustrates the preferred embodiment of this invention, comprising a lifting surface with three or more "controlled" fluid-foil sections, in which the section with the least mean-line camber 1 is located at the root of the lifting surface, the section with the greatest mean-line camber 3 is located at the fluid-dynamically effective tip of the lifting surface (the actual tip fairing of the lifting surface may comprise a faired three-dimensional body without any identifiable mean-line camber, which is not of any consequence in the application of the subject invention), and one or more interjacent fluid-foil sections 2 are selected following the method outlined below, said interjacent fluid-foil sections having values of the mean-line camber at variance with the values 4 obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root and the fluid-foil section located at the tip of the lifting surface, provided that the respective values of the mean-line camber of the interjacent fluid-foil sections neither exceed the mean-line camber of the tip section nor fall below the mean-line camber of the root section. It shall be understood that the preceding considerations apply to all types of lifting surfaces regardless of the respective thickness ratios of the root and tip sections. It shall also be understood that additional considerations relative to the respective thickness ratios of the various controlled fluid-foil sections are presented herein for lifting surfaces wherein the thickness ratio of the root section is the greatest, and the thickness ratio of the tip section is the smallest, respectively, of any fluid-foil section employed in the lifting surface.

Figure 2 illustrates the preferred manner in which this invention, through the employment of the aforementioned method of fluid-foil selection, achieves the establishment of a curvilinear polygon 5 describing the spanwise distribution of maximum attainable section lift coefficients, said curvilinear polygon being so shaped that it envelops closely the curve 6 describing the spanwise distribution of the actually prevailing section lift coefficients, except that beyond the spanwise point 7 at which the highest actually prevailing section lift coefficient occurs the maximum attainable section lift coefficient exceeds substantially the actually prevailing section lift coefficient, so that the stall inception occurs near mid-semispan, spreads more prevalently inboardward and to a smaller extent outboardward, and does not involve the extreme tip of the lifting surface prior to the breakdown of the fluid flow over the entire remaining lifting surface.

As used herein the curvilinear polygon 5 describing the spanwise distribution of maximum attainable section lift coefficients is established by the respective values of the maximum attainable lift coefficients of the root section 9, the tip section 8, and the third or additional control section 11, and by the respective maximum attainable lift coefficients 5 of the sections obtained by conventional fairing between each pair of controlled sections 9—11, 11—8, etc.

The curve 6 describing the spanwise distribution of the actually prevailing section lift coefficients at the maximum lift coefficient of the lifting surface is obtained by conventional methods of experimentally verified calculation for the desired lifting surface, taking into consideration the plan-form, effective aerodynamic washout, section lift-curve-slope characteristics, etc.

The term "envelopment" as used herein signifies the establishment of curvilinear polygon 5 on the convex side of curve 6, wherein each individual branch 9—11, 11—8, and so forth of the curvilinear polygon 5 is tangent or nearly tangent to curve 6.

Figure 3 illustrates the stall progression resulting from the employment of the subject method of this invention. The curves 12, 13, 14, 15, and 16 indicate, in their orderly progression, the extent of the stalled lifting-surface area at angles of attack greater than the angle of attack at which stall inception 12 first occurs. This spanwise far-reaching yet gradual spread of the stalled area prevents the formation of a deep local stall in a chordwise or depthwise sense at any one spanwise station. Steep spanwise pressure differences between unstalled sections and stalled sections, and hence deep spanwise cross-flows, are thereby effectively prevented.

The prevalently inboardward development of the stalled area not only produces the desired timely stall warning in the form of a gentle tail shake at a speed slightly in excess of stalling speed, but serves also to reduce the downwash of the fluid flow aft of the lifting surface in the space usually occupied by the horizontal stabilizer, so that an upwardly directed lift-force increment is made to act on the horizontal stabilizer, thereby imposing a nose-down pitching moment on the craft that induces the craft to return to smaller angles of attack and brings to a halt any further progress and intensification of the stalling process by precluding any increase in angle of attack beyond the stalling angle.

The following specification outlines the method employed in the design of the subject lifting surface of this invention, whereby to select the most opportune values of fluid-foil section mean-line camber and fluid-foil section thickness ratio required to achieve the objects of the instant invention:

To apply the subject method of this invention it is actually necessary to know only the plan form of the lifting surface and the desired stall pattern. Inasmuch as practical considerations other than those pertaining solely to the control of the stalling characteristics ordinarily predetermine certain design parameters of the lifting surface, preferred embodiments of the subject method of this invention are hereinafter explained for two typical combinations of predetermined basic design parameters:

In the first typical configuration the following design parameters, for example, are assumed to be given a priori: (*a*) the plan form of the lifting surface, based on structural and practical design considerations; (*b*) the series of fluid-foil sections to be employed, based on high-speed and other performance requirements; (*c*) the maximum permissible effective aerodynamic washout, based on drag considerations and structural bending-moment limitations; (*d*) the thickness ratio of the fluid-foil section at the root, based on the critical-Mach-Number requirements and structural weight considerations; (*e*) the thickness ratio of the fluid-foil section at the tip, based on practical space requirements for control-surface balances, etc.; (*f*) the mean-line camber of the fluid-foil section at the tip, based on the requirement of adequate torsional lifting-surface stiffness at high speed.

The subject method of this invention is employed firstly to design the lifting surface without any effective aerodynamic washout, that is, with the three or more controlled fluid-foil sections placed at such an angle of incidence with respect to the reference chord plane of the lifting surface that the said fluid-foil sections operate at their respective zero-lift angles of attack when the entire lifting surface operates at its angle of attack for zero overall lift.

Based on fundamental experimental wind-tunnel data available for the pre-selected series of fluid-foil sections, graphs are plotted showing the variation in the maximum attainable section lift coefficient versus the mean-line camber, thickness ratio, and Reynolds number, respectively; similar graphs are plotted showing the variation in the section zero-lift angle of attack versus the mean-line camber, thickness ratio, and Reynolds number, respectively.

The approximate maximum attainable lift coefficient of the entire lifting surface for appropriate values of the Reynolds number is estimated, for example, by dividing the maximum attainable section lift coefficient of the tip section 8 (obtained from the aforementioned wind-tunnel data) by the highest spanwise value of the "additional section lift coefficient

$$C_{l_{a_1}}$$

(as defined in Army-Navy-Commerce ANC-1(1) entitled "Spanwise Air-Load Distribution"), as follows:

$$C_{L_{max}}=\frac{C_{l_{max\ tip}}}{C_{l_{a_{1_{highest}}}}}$$

this equation yields that lift coefficient of the entire lifting surface at which the most highly loaded section 7 carries a section lift coefficient substantially equal to the maximum attainable section lift coefficient 8 of the fluid-foil section employed at the tip.

The spanwise distribution 6 of the actually prevailing section lift coefficients is then calculated for the maximum lift coefficient $C_{L_{max}}$ of the entire lifting surface, following one of the conventional calculation methods, for example, the method outlined in the Army-Navy-Commerce Manual ANC-1(1).

For the Reynolds number and the pre-selected thickness ratio of the root section, the required value of mean-line camber is determined from the graph showing the experimentally determined variation of the maximum attainable section lift coefficient with varying mean-line camber, selecting that value of the mean-line camber that produces a maximum attainable section lift coefficient 9 equal to or slightly superior to the section lift coefficient 10 actually prevailing over the root section.

For the spanwise location of the third and additional controlled sections 2 and 11, the subject method of this invention utilizes preferringly locations between the spanwise point of the highest actually prevailing section lift coefficient 7 and the root 10 of the lifting surface; the most efficient interval wherein to locate the third controlled section lies between the spanwise point of the highest actually prevailing section lift coefficient 7 and the spanwise point located twice as distantly from the tip as point 7, with a preferable optimum at the point 17, where the tangent to the inboard portion of the curve of spanwise distribution of the actually prevailing section lift coefficients 18 intersects the horizontal tangent 19 to the same curve, as shown in Figure 4.

It will be understood, however, that inescapable practical design considerations may require that the additional controlled sections 2 and 11 be placed at spanwise stations located inside power plant nacelles or at those spanwise stations where the lifting surface is mechanically jointed for sudden changes in plan-form taper, or sweepback, as is the case in craft with removable or foldable outboard panels.

The Reynolds number is calculated for the third controlled section; the thickness ratio obtainable at the third section by straight-line interpolation between the root section and the tip section is also determined. For the Reynolds number and thickness ratio thus determined, the required value of mean-line camber is found from the graph showing the experimentally determined variation of the maximum attainable section lift coefficient with varying mean-line camber, selecting that value of the mean-line camber which produces a maximum attainable section lift coefficient 11 and 17 equal to or slightly superior to the highest actually prevailing section lift coefficient 7.

From the foregoing, it will be readily seen that the lifting surface obtained by the invention, and defined by the curvilinear polygon 5, embodies the combination of an airfoil section 1 or 9 having the smallest mean line camber at the root, an airfoil section 3 or 8 having the greatest mean line camber at the tip, and one or more interjacent controlled sections 2 or 11, having values of the mean line camber at variance with the values 4 obtainable at the respective spanwise stations by means of straight line fairing between the root section and the tip section.

If the required maximum attainable section lift coefficient for the interjacent section 11 cannot be obtained with a mean-line camber not exceeding the mean-line camber of the tip section, a value equal to or slightly less than the mean-line camber of the tip section is selected. The maximum attainable section lift coefficient of the interjacent section is then increased by changing the section thickness ratio in the proper sense, usually downward, until either the required maximum attainable section lift coefficient 11 is obtained, or until structural considerations interfere with the continuance of this procedure. If this process does not offer a conclusive result, which is rare, a small amount of effective aerodynamic washout is then introduced, ½° to 1° in each step of the application of the method, wherein the total effective aerodynamic washout is distributed in appropriate fashion between the controlled sections and where the total washout is less than the maximum permissible washout as defined in the aforelisted initial design assumptions. The entire heretofore specified procedure including the establishment of a curve 6 conforming to the washout chosen, is then repeated for the selected amount of effective aerodynamic washout, until the desired results as illustrated in Figures 2 and 3 are attained.

A typical example of the application of the principles of this invention to one well-known type of lifting surface is as follows: Here we assume a planform taper ratio of three to one, an aspect ratio of ten, a total effective aerodynamic washout of zero degrees, a constant section thickness ratio of twelve per cent along the entire semi-span, the utilization of "64—" series NACA "low-drag" fluid-foil sections, a mean-line camber of the root section 1 characterized by an "ideal lift coefficient" C_{l_i} equal to 0.1, and a mean-line camber of the tip section 3 characterized by an "ideal lift coefficient" C_{l_i} equal to 0.45. The term "ideal lift coefficient" is to be interpreted as defined by the National Advisory Committee for Aeronautics nomenclature and is herein used as a parameter characteristic of the mean line camber of a fluid foil section. Calculations based on conventional methods will indicate that a lifting surface having the above general design parameters will experience, at its maximum resultant lift coefficient, a distribution of section lift coefficients as illustrated in curve 6.

Following the procedures hereinbefore described, we achieve in the above-outlined construction the desirable stalling characteristics taught by this invention through the use of a controlled fluid-foil section 2 or 11 at a station approximately 55 per cent of the semi-span from the root and with an effective aerodynamic washout of zero degrees with respect to the root section, wherein the mean-line camber of the interjacent controlled section 2 or 11 is characterized by an "ideal lift coefficient" C_{l_i} equal to 0.35. In this structural example the mean-line camber of the interjacent controlled section 2 or 11 is greater than that of the root section 1 or 9, smaller than that of the tip section 3 or 8, and greater than that of the interpolated section 4 obtainable at the 55-per-cent semi-span station by means of straight-line fairing between sections 1 and 3, and which accomplishes the envelopment of curve 6 by the curvilinear polygon 5.

In another typical example, a lifting surface is assumed as having substantially identical basic design geometry as the preceding example, except for a structurally desirable root thickness ratio of twenty-three per cent, a tip thickness ratio of seven per cent, a total effective aerodynamic washout of one degree, and a thickness ratio of fifteen per cent at an interjacent station located at approximately 60 per cent of the semi-span.

Again following the procedure of this invention we achieve in the abovedescribed construction the desirable stalling characteristics taught by this invention through the use of a controlled fluid-foil section 2 or 11 at the station located approximately 60 per cent of the semi-span from the root and with an effective aerodynamic washout of 0.5 degree with respect to the root section, wherein the mean-line camber of the interjacent controlled section 2 or 11 is characterized by an "ideal lift coefficient" C_{l_i} equal to 0.12. In this structural example the mean-line camber of the interjacent controlled section 2 or 11 is greater than that of the root section 1 or 9, smaller than that of the tip section 3 or 8, and smaller than that of the interpolated section 4 obtainable at the 60-per-cent semi-span station by means of straight-line fairing between sections 1 and 3, and which accomplishes the envelopment of curve 6 by the curvilinear polygon 5.

(2) The second typical configuration differs from the first in that the thickness ratio of the tip section 3 is not predetermined. Hence, the following design parameters are assumed to be given a priori: (*a*) the plan form of the lifting surface: (*b*) the series of fluid-foil sections to be employed and their fluid-dynamic characteristics; (*c*) the maximum permissible effective aerodynamic washout; (*d*) the thickness ratio of the fluid-foil section at the root; (*e*) the mean-line camber of the fluid-foil section at the tip.

In this case where the thickness ratio of the tip section is not predetermined but is left to the judgment of the fluid-dynamical design engineer, the subject method of this invention employs to good advantage a peculiarity observed in the variation of the maximum attainable section lift coefficient with varying section thickness ratio. Most series of related fluid-foil sections reach their absolutely highest maximum section lift coefficient (for a given mean-line camber and Reynolds number) at a certain experimentally determined thickness ratio, usually between 12% and 16%. Sections with thickness ratios greater or smaller than optimum attain less than the absolutely maximum section lift coefficient. If, as illustrated in Figure 5, a thickness ratio smaller than optimum is used at the tip 20 of a lifting surface, where the actually prevailing section lift coefficients are greatly below their highest spanwise value 22, the fluid-foil section with the optimum thickness ratio can be located at a spanwise station 21 a small distance inboard of the tip, near the spanwise station 22 at which the highest actually prevailing section lift coefficient is encountered. Here it will be understood that the mean-line camber of the interjacent controlled section 2 may be greater or smaller than that of the aforementioned section 4, depending on the range of section thickness ratios encountered between the root and the tip of the lifting surface.

In this case the subject method of this invention is modified to the extent that, in calculating the spanwise distribution of the actually prevailing section lift coefficients 23, the maximum lift coefficient $C_{L_{max}}$ of the entire lifting surface shall be determined not on the basis of the maximum attainable section lift coefficient of the tip section, but on the basis of the absolutely maximum attainable section lift coefficient 21, that is, for the section of optimum thickness ratio, as follows:

$$C_{L_{max}} = \frac{C_{l_{max\ abs.}}}{C_{l_{a_{l_{highest}}}}}$$

The thickness ratio of the fluid-foil section at the tip of the lifting surface is then so chosen that the section 21 with optimum thickness ratio for absolutely maximum attainable section lift coefficient lies between the spanwise station of highest actually prevailing section lift coefficient 22 and the tip 20, unless structural and other design criteria interfere by establishing a minimum section thickness ratio.

If the designer intends to achieve positive stall inception in a certain spanwise panel of the lifting surface, the subject method of this invention provides that in either of the aforedescribed design procedures the mean-line camber and thickness ratios, as well as the spanwise location, of the sections comprised within or adjacent to the panel for which stall inception is desired be so selected that within the "stall inception panel" the curve of maximum attainable section lift coefficients lies slightly below the curve of actually prevailing section lift coefficients, without modifying the aforedescribed relationship of the maximum attainable section lift coefficients and the actually prevailing section lift coefficients on the remainder of the semispan of the lifting surface outside of the "stall-inception panel" proper.

If, in any of the aforedescribed cases, the lifting surface under consideration is modified by excrescences such as, for example, power-plant nacelles, or flaps that modify the local zero-lift angle and the local maximum attainable section lift coefficient, the calculation of the spanwise distribution of the effective washout and the maximum attainable section lift coefficients takes due account of the effects of these modifications by introducing "equivalent values" of the effective washout and section mean-line camber into the subject method of this invention.

Upon completion of the procedure outlined for the subject method of this invention, the zero-lift angles of the fluid-foil sections selected thusly are determined for their respective mean-line cambers, thickness ratios, and Reynolds numbers, and each fluid-foil section is set properly with respect to the reference chord plane of the lifting surface, so that the desired effective washout is achieved.

By practicing my invention a lifting surface can be designed and constructed to achieve the objects heretofore stated.

Numerous flight tests and wind-tunnel tests in reputable wind-tunnels such as the California Institute of Technology, the Massachusetts Institute of Technology, the various wind tunnels of the National Advisory Committee for Aeronautics, and elsewhere have demonstrated convincingly that each of the objects of this invention has been fully achieved. The tests were performed on numerous wing models, on sailplanes, and on models of at least five aircraft designs of widely varying design scope employing a wide variety of airfoil series. Force-test records, photographic records, and cinematographic records of the tests substantiate the attainment of the objects of this invention.

The inventor wishes it to be clearly understood that the greatly improved and generally judged satisfactory stalling characteristics of the wings (and other lifting surfaces) designed and constructed according to the subject method of this invention are directly attributable to the use of three (or more) controlled fluid-foil sections selected according to the hereinbefore specified method of this invention, and to the aforedescribed method employed in the design of such lifting surfaces.

This invention accomplishes an important improvement in the art, and the discoveries herein disclosed are of great value to all types of aircraft (as well as to craft operating in other fluids), throughout their entire operating range, and especially in the critical low-speed operation where steadiness of lift and lift variation, stability of the craft, control effectiveness, and smoothness and stability of control forces are of vital importance for the safety and efficiency of the craft; also in violent maneuvers at high speeds when high lifting-surface lift coefficients comparable with those occurring at the low-speed stall are encountered and even temporarily surpassed.

I claim:

1. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and the third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the mean-line camber of the interjacent fluid-foil sections are greater than the values of the mean-line camber obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface.

2. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and the third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the mean-line camber of the interjacent fluid-foil sections are at variance with the values of the mean-line camber obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface, said three or more controlled fluid-foil sections having values of the mean-line camber selected in such manner that the resulting spanwise distribution of maximum attainable section lift coefficients of the three or more controlled sections forms a curvilinear polygon enveloping a curve representing the spanwise distribution of section lift coefficients for a given planform actually prevailing at the maximum attainable lift coefficient of the lifting surface.

3. A lifting surface with three or more controlled fluid-foil sections, adapted to provide stall inception within a predetermined interval of spanwise stations in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and the third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the mean-line camber of the interjacent fluid-foil sections are at variance with the values of the mean-line camber obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface, said three or more controlled fluid-foil sections having values of the mean-line camber selected in such manner that the resulting spanwise distribution of maximum attainable section lift coefficients of the three or more controlled sections forms a curvilinear polygon enveloping a curve representing the spanwise distribution of section lift coefficients actually prevailing at the maximum attainable lift coefficient of the lifting surface, and that the said resulting spanwise distribution of maximum attainable section lift coefficients for a given planform be so shaped that the first intersection with the spanwise distribution of actually prevailing section lift coefficients occurs in that interval of spanwise stations for which stall inception is to be obtained.

4. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber and greatest thickness ratio is located at the root, the second section with the greatest mean-line camber and smallest thickness ratio is located a the fluid-dynamically effective tip, and the thir or additional fluid-foil sections are located at sta tions interjacent between the root and the ti wherein the values of the thickness ratio of th interjacent fluid-foil sections are greater tha the values of the thickness ratio obtainable a the respective spanwise stations by means o straight-line fairing between the fluid-foil sec tion located at the root of the lifting surface an the fluid-foil section located at the tip of th lifting surface.

5. A lifting surface with three or more con trolled fluid-foil sections, in which the first sec tion with the smallest mean-line camber an greatest thickness ratio is located at the root, th second section with the greatest mean-line cam ber and smallest thickness ratio is located at th fluid-dynamically effective tip, and the third o additional fluid-foil sections are located at sta tions interjacent between the root and the ti wherein the values of the thickness ratio of th interjacent fluid-foil sections are at variance wit the values of the thickness ratio obtainable a the respective spanwise stations by means c straight-line fairing between the fluid-foil sec tion located at the root of the lifting surface an the fluid-foil section located at the tip of th lifting surface, said three or more controlle fluid-foil sections having values of the thickne ratio selected in such manner that the resultin spanwise distribution of maximum attainable se tion lift coefficients of the three or more con trolled sections forms a curvilinear polygo enveloping a curve representing the spanwise di tribution of section lift coefficients for a give planform actually prevailing at the maximu attainable lift coefficient of the lifting surface

6. A lifting surface with three or more con trolled fluid-foil sections adapted to provide sta inception within a predetermined interval spanwise stations, in which the first section wit the smallest mean-line camber and greate thickness ratio is located at the root, the secon section with the greatest mean-line camber an smallest thickness ratio is located at the flui dynamically effective tip, and the third or add tional fluid-foil sections are located at statio interjacent between the root and the tip, wherei the values of the thickness ratio of the interja cent fluid-foil sections are at variance with th values of the thickness ratio obtainable at th respective spanwise stations by means of straigh line fairing between the fluid-foil section locate at the root of the lifting surface and the flui

foil section located at the tip of the lifting surface, said three or more controlled fluid-foil sections having values of the thickness ratio selected in such manner that the resulting spanwise distribution of maximum attainable section lift coefficients of the three or more controlled sections forms a curvilinear polygon enveloping a curve representing the spanwise distribution of section lift coefficients actually prevailing at the maximum attainable lift coefficient of the lifting surface, and that the said resulting spanwise distribution of maximum attainable section lift coefficients for a given planform be so shaped that the first intersection with the spanwise distribution of actually prevailing section lift coefficients occurs in that interval of spanwise stations for which stall inception is to be obtained.

7. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and one of the interjacent fluid-foil sections is located near a spanwise point where a tangent to the inboard portion of a curve representing the spanwise distribution of actually prevailing section lift coefficients for a given planform intersects a substantially horizontal tangent to the highest point of the same curve, wherein the values of the mean-line camber of the interjacent fluid-foil sections are greater than the values of the mean-line camber obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface.

8. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber and greatest thickness ratio is located at the root, the second section with the greatest mean-like camber and smallest thickness ratio is located at the fluid-dynamically effective tip, and one of the interjacent fluid-foil sections is located near a spanwise point where a tangent to the inboard portion of a curve representing the spanwise distribution of actually prevailing section lift coefficients for a given planform intersects a substantially horizontal tangent to the highest point of the same curve, wherein the values of the thickness ratio of the interjacent fluid-foil sections are greater than the values of the thickness ratio obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface.

9. A lifting surface with three or more controlled fluid-foil sections and having a highest actually prevailing section lift coefficient at a predetermined spanwise station, in which the first section with the smallest mean-line camber and greatest thickness ratio is located at the root, the second section with the greatest mean-line camber and smallest thickness ratio is located at the fluid-dynamically effective tip, and the third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the mean-line camber of the interjacent fluid-foil sections are at variance with the values of the mean-line camber obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface, and wherein the aforesaid fluid-foil section at the tip of the lifting surface has a thickness ratio smaller than the optimum thickness ratio for absolutely maximum attainable section lift coefficient of the fluid-foil series employed, so that a fluid-foil section having the optimum thickness ratio obtained by conventional interpolation between two of the controlled sections lies a short distance inboard of the tip of the lifting surface, near the spanwise station at which the highest actually prevailing section lift coefficient occurs.

10. A lifting surface with three or more controlled fluid-foil sections and having a highest actually prevailing section lift coefficient at a predetermined spanwise station, in which the first section with the smallest mean-like camber and greatest thickness ratio is located at the root, the second section with the greatest mean-line camber and smallest thickness ratio is located at the fluid-dynamically effective tip, and third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the thickness ratio of the interjacent fluid-foil sections are greater than the values of the thickness ratio obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface, and wherein the aforesaid fluid-foil section at the tip of the lifting surface has a thickness ratio smaller than the optimum thickness ratio for absolutely maximum attainable section lift coefficient of the fluid-foil series employed, so that a fluid-foil section having the optimum thickness ratio obtained by conventional interpolation between two of the controlled sections lies a short distance inboard of the tip of the lifting surface, near the spanwise station at which the highest actually prevailing section lift coefficient occurs.

11. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and the third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the mean-line camber of the interjacent fluid-foil sections are smaller than the values of the mean-line camber obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface.

12. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber and greatest thickness ratio is located at the root, the second section with the greatest mean-line camber and smallest thickness ratio is located at the fluid-dynamically effective tip, and the third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the thickness ratio of the interjacent fluid-foil sections are smaller than the values of the thickness ratio obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface.

13. A lifting surface with three or more con-

trolled fluid-foil sections, in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and one of the interjacent fluid-foil sections is located near a spanwise point where a tangent to the inboard portion of a curve representing the spanwise distribution of actually prevailing section lift coefficients for a given planform intersects a substantially horizontal tangent to the highest point of the same curve, wherein the values of the mean-line camber of the interjacent fluid-foil sections are smaller than the values of the mean-line camber obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface.

14. A lifting surface with three or more controlled fluid-foil sections, in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and one of the interjacent fluid-foil sections is located near a spanwise point where a tangent to the inboard portion of a curve representing the spanwise distribution of actually prevailing section lift coefficients for a given planform intersects a substantially horizontal tangent to the highest point of the same curve, wherein the values of the thickness ratio of the interjacent fluid-foil sections are smaller than the values of the thickness ratio obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface.

15. A lifting surface with three or more controlled fluid-foil sections and having a highest actually prevailing section lift coefficient at a predetermined spanwise station, in which the first section with the smallest mean-line camber is located at the root, the second section with the greatest mean-line camber is located at the fluid-dynamically effective tip, and the third or additional fluid-foil sections are located at stations interjacent between the root and the tip, wherein the values of the thickness ratio of the interjacent fluid-foil sections are smaller than the values of the thickness ratio obtainable at the respective spanwise stations by means of straight-line fairing between the fluid-foil section located at the root of the lifting surface and the fluid-foil section located at the tip of the lifting surface, and wherein the aforesaid fluid-foil section at the tip of the lifting surface has a thickness ratio smaller than the optimum thickness ratio for absolutely maximum attainable section lift coefficient of the fluid-foil series employed, so that a fluid-foil section having the optimum thickness ratio obtained by conventional interpolation between two of the controlled sections lies a short distance inboard of the tip of the lifting surface, near the spanwise station at which the highest actually prevailing section lift coefficient occurs.

MAURICE ADOLPH GARBELL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,547,644	Cronstedt	July 28, 1925
1,817,275	Soldenhoff	Aug. 4, 1931
1,839,349	Sigrist	Jan. 5, 1932
1,890,079	Focke	Dec. 6, 1932

PLAINTIFFS' EXHIBIT No. 12

[Western Union Message]

BY16 113 NT. Miami, FLO., Jul 20

F. H. Fleet, President Consair

Can You Offer Advanced Field of Activity of Experienced Aeronautical Engineer. Well Versed in Airplane and Engine Design, Performance Analysis and Research. Have Three Successful Original Designs to My Credit. For the Past Three Years Have Taught Applied Mechanics. Strength of Materials, Mechanism, Advanced Structural Design, Aerodynamics, Aeronautical Meterology in Leading Aeronautical Engineering School West Coast and University of California. Am at Present Concluding Training Program in Transatlantic Airlines School Here. Two Original Technical Text Books Just Coming Off Presses New York Publisher as Well as Many Articles Published in Leading Newspapers and Magazines. Perfect Knowledge All Important European Languages Including Russian. Wire if Interested to Forestall Acceptance Other Offer. 1801 Southwest 23 Terr., Miami.

DR. MAURICE A. GARBELL.

1801 23.
1114A

Admitted November 21, 1950.

PLAINTIFFS' EXHIBIT No. 13

Western Union
[Telegram]

July 21, 1942.

Dr. Maurice A. Garbell,
1801 Southwest 23 Terr.
Miami, Florida.

Reference Your Telegram to R. H. Fleet We Have Openings in Structures Preliminary Design and Aerodynamics for Aeronautical Engineers. We Are Interested in Knowing the Kind of Connection You Are Seeking, the Salary Expected and Whether or not You Are an American Born Citizen.

B. W. SHEAHAN,
Consolidated Aircraft Corporation.

cc: Employment Dept.
Engr. File

Admitted November 21, 1950.

PLAINTIFFS' EXHIBIT No. 14

Maurice A. Garbell, D. Sc.

1801 SW 23rd Terrace,
Miami, Florida,
July 25, 1942.

Consolidated Aircraft Corporation,
San Diego, California.

Attention: Mr. B. W. Sheahan.

Gentlemen:

I have for acknowledgment receipt of your telegram of July 21st reading as follows:

> "Reference your telegram to R. H. Fleet we have openings in structures, preliminary design, and aerodynamics for aeronautical engineers. We are interested in knowing the kind of connection you are seeking, the salary expected, and whether or not you are an American born citizen."

I am primarily interested in being placed where my ability may find its greatest usefulness in your organization, namely preliminary design or research engineering.

In order that you may gain some idea of actual accomplishments, I respectfully refer you to "Aviation," June, 1939, the lead article, showing photograph of "Arcore," one of three successful designs of which a series of fifty ships were built by me. To

Plaintiffs' Exhibit No. 14—(Continued)

summarize the technical value of such advanced developments for power plane design, I might mention that all these ships had aspect ratio greater than 15, single spar wings, and monococque fuselages, stressed for aerobatics and thunderstorm soaring conditions. My planes were fitted with self-stabilizing wing-spoilers for emergency dives, zero-yaw differential aileron control and other improvements intended for added safety, maneuverability, and ease of assembly. These planes were designed, built, and successfully flown by a research institute for motorless flight under my direction, guidance, and supervision.

It is needless for me to digress further into the detailed value of applying these principles to power planes; Consolidated's adoption and development of the Davis wing, for example, indicates your recognition of their importance.

Incidentally, in connection with citizenship, I might mention that the United States Government granted me full citizenship through spontaneous and urgent intervention of the Office of the Chief of Staff, Army Air Corps, War Department, Washington, D. C., with the Naturalization Bureau after a rigid and thorough investigation. The recommendation was the result of the complete knowledge of my activities in this country and abroad by a member of the Staff Office and the recognition of my value to the present war effort:

As to salary expected, I prefer that you make an

Plaintiffs' Exhibit No. 14—(Continued)

offer to me, commensurate with the position available.

I shall look forward to your further advice, and if you are interested an early reply will be appreciated to forestall my final decision between other seemingly interesting positions offered me within the past few days.

Yours very truly,

/s/ DR. MAURICE A. GARBELL.

Maurice A. Garbell, D. Sc.

August 7, 1942.

Consolidated Aircraft Corporation,
San Diego, California.

Transcript of subjects and courses studied:

Institute of Technology, Berlin Charlottenburg:
(Technische Hochschule)

Differential and integral calculus,
Theory of numbers,
General Mechanics (elementary applied mechanics and kinematics),
Drafting,
Descriptive geometry,
General physics,
General and inorganic chemistry,
Technology of metals,
Economy,
History of industrial development.

Plaintiffs' Exhibit No. 14—(Continued)

Institute of Technology, Milan:
(Regio Istituto di Ingegneria & Regio Politecnico)

Differential and integral calculus (2 years.)
Analytic and projective geometry (1 yr.)
Descriptive geometry (2)
Artistic sketching (1)
Architectural drawing (1)
Engineering drawing (1)
General and experimental physics (2)
Industrial physics (general and industrial thermodynamics—1)
Analytical mechanics (1)
Applied mechanics and strength of materials (1)
Structures (1)
Science of mechanism (1 yr.)
General and inorganic chemistry (1)
Organic chemistry (audited lecture course—1)
Qualitative analytical chemistry (aud. lecture course, completed laboratory—1)
Industrial and agricultural chemistry (2)
Machine design (1)
Hydraulics (1)
Thermal and hydraulic engines (1)
Internal combustion engines (1)
Electro-engineering (1)
Building materials (1)
Metallurgy and metallography (1)
Industrial technology (1)
Topography and surveying (1)

Plaintiffs' Exhibit No. 14—(Continued)

Geology (1)
Mineralogy (1)
Industrial planning (1)
Industrial economy (1)
Transportation (1)
Appraisal of industrial plants and machinery (1)
Highway and railroad engineering (1)
Aerodynamics (1)

Thesis for doctor's degree:

a) design of a 9-cylinder 750 HP radial engine,

b) analysis of the possibilities for steam turbines on large stratosphere airplanes.

Minor theses:

a) Geology: geological survey of a certain area north of Milan, for a joint land and water airport.

b) Civil structures: a wooden hangar for a small chemical factory, and a concrete structure for a swimming pool.

c) Industrial planning: preliminary planning for a factory producing aluminum alloy cylinders for aircraft engines.

d) Aerodynamics: a report on four years of activity as a Manager of the Research In-

Plaintiff's Exhibit No. 14—(Continued)

stitute for Soaring Flight, the designs brought to completion, special projects, organization of the experimental shop, and flying activities.

/s/ MAURICE A. GARBELL.

Admitted November 21, 1950.

PLAINTIFFS' EXHIBIT No. 15

Form 182-R

Consolidated Aircraft Corporation
San Diego, California

Employment Agreement

I represent the statements made in my application for employment, submitted to Consolidated Aircraft Corporation on this date, to be correct to the best of my knowledge and belief; that no attempt has been made to conceal pertinent information; that all facts in that application are open to investigation and verification by Consolidated Aircraft Corporation; and I agree to hold Consolidated Aircraft Corporation and persons named in my application blameless should the information received from those persons result in my dismissal by Consolidated Aircraft Corporation.

I also agree to read and abide by "Laws of the United States and Proclamation of the President of the United States Relating to Classified Air Corps Projects" pertaining to espionage and sabotage which is printed on the reverse side of this sheet.

Plaintiffs' Exhibit No. 15—(Continued)

I hereby acknowledge receipt of Consolidated Aircraft Corporation's employee handbook and agree to abide by the rules and regulations set forth therein.

/s/ MAURICE A. GARBELLL.

Date: 9-7-42

Application for Employment

Consolidated Aircraft Corporation
Industrial Relations Department

Employment Division
1845 Moore Street, San Diego, California

[Stamped]: Plant Protection Sep. 8, 1942.

This Application for Employment Is Submitted to Consolidated Aircraft Corporation with Full Understanding of the Following Listed Instructions and Information:

1. Application to Be Filled Out in Own Handwriting. (Do not Print.) (Do not Type.)

2. Make Sure That Each and Every Question Has Been Answered In Full.

3. Make Sure the Employment History Section Is Complete in Detail.

4. Make Sure Your References Are Persons Who Have Known You for a Long Period of Time and Are not Relatives or Previous Employers.

Plaintiffs' Exhibit No. 15—(Continued)

5. It Is Understood That You Represent the Statements Made by You in This Application to Be Correct to the Best of Your Knowledge and Belief; That No Attempt Has Been Made to Conceal Pertinent Information; That All Facts Are Open to Investigation and Verification by Consolidated Aircraft Corporation: and Further That You Agree to Hold Consolidated Aircraft Corporation and Persons Named Herein Blameless Should Such Information Result in the Revocation of This Application, and/or Subsequent Dismissal From Employment.

6. It Is Further Understood That if Accepted for Employment, You Agree to Read and Abide by the "Laws of the United States and Proclamation of the President of the United States Relating to Classified Air Corps Projects," Pertaining to Espionage and Sabotage, a Copy of Which Is Printed in the Rules for Employees of the Consolidated Aircraft Corporation.

7. Native Born Applicants Must Present Birth Certificate or Other Official Documentary Evidence of Citizenship.

8. Foreign Born Applicants Must Present Final Citizenship Papers.

Date: August 7, 1942.

Name in Full: (Print) (Last) Garbell, (First) Maurice, (Middle) Adolph.

Social Security No.: 062-14-8883.

Plaintiffs' Exhibit No. 15—(Continued)

Local Address: (Street and Number) 1801 SW 23rd Terrace, (City) Miami, (State) Florida.

Phone Number: 48-1980.

Permanent Address: (Street and Number) 1714 Lake Street, (City) San Francisco, (State) California.

Phone Number: BAyview 9186.

Former Address: (Street and Number) 1106 Sherman Street, (City) Alameda, (State) California.

How Long There? Oct., 39—Nov., 40.

Former Address: (Street and Number) 3026-84th Street, (City) Jackson Heights, (State) New York.

How Long There? Feb., 39—Oct., 39.

Former Address: (Street and Number) 16 Hamburgas iela, (City) Riga-Meza Parks, (State) Latvia.

How Long There? 1933-1939.

Former Address: (Street and Number) 2 Jura Alunana iela, (City) Riga, (State) Latvia.

How Long there? Family resid. for two generations.

Date of Birth: (Month) May, (Date) 21, (Year) 1914.

Place of Birth: (City) Moscow, (State) Russia.

Nationality: Russian.

Plaintiffs' Exhibit No. 15—(Continued)

This Line to Be Filled in by Foreign Born Citizens Only:

Date of Entry: Feb. 28, 1939.
Port of Entry: New York City, N. Y.
Date of Second Papers: 5-5-42.

Where Issued? Superior Court, County of San Francisco, California. No. 5029278.

Draft Board Location: (City) Alameda, (State) California.
Draft Board No.: 62
Order No.: 728
Class: 2-B
Date of Class: 5-20-42

Please use following space for reason of your present classification: Essential in defense work.

Are you a member of National Guard or Reserves? no. If so, what? —

Give military or naval service, U. S. or other countries: none.

Have you ever used any other name? no.

If so, what? —
Have you ever been convicted of a felony? no.
If so, explain in following space: —
Male: yes. Female: —
Color: white.
Single: — Married: yes.
Divorced: — Widowed: —
Height: 5'11". Weight: 175 lbs.
Color of Hair: dark brown.

Plaintiffs' Exhibit No. 15—(Continued)

Color of Eyes: brown.
Scars, Birthmarks, etc.: none.
Live with Wife: yes.
Live with Parents: no.
Live with Relatives: no.
Live Alone: no.
Wife Work? no.
Number of Dependent Children: none.
Number of Dependent Parents: 1.
Number of Other Dependents: 1.
Own Home: no. Rent: yes.
Room: — Board: —
How long in California? Oct. '39-May, 1942.
What Counties? Alameda & San Francisco.
How long in San Diego? —
Are Dependents in San Diego? no.
If not, where? Wife with me, Mother at present in British Mandate of Palestine.
Are you going to bring them here? no (except wife)
Father's Name: Edward Garbell.
Birthplace: Goldingen, Russia.
Present Address: deceased 1919.
Mother's Name: Flora, nee Feitelberg.
Birthplace: Goldingen, Russia.
Present Address: 23 Ussishkin St., Jerusalem (Palestine).
Wife (or Husband) Esther, nee Feitelberg.
Birthplace: San Francisco, California.

Plaintiffs' Exhibit No. 15—(Continued)

Present Address: 1801 SW 23rd Terrace, Miami, Florida.

Names and Addresses of Near Relatives now residing in Foreign Countries: Mother (please refer to above address)

Names and Relationship of Relatives Employed by this Company: none.

Do you have Relatives working for other Aircraft Companies? no. Which Companies? —

List Clubs, Societies, and Fraternal Organizations of which you are a Member: Institute of the Aeronautical Sciences, American Meteorological Society, Soaring Society of America, International Research Committee for Motorless Flight.

What are your hobbies and other interests? Sailing, soaring, swimming, photography, meteorology.

SCHOOL	No. Yrs.	Year Left	Graduated	Degree	Major Subjects and Courses Liked Best	NAME OF SCHOOL	City and State
...le	3	1923	yes	cert. of graduation	normal 4-year course	Dr. Busch's private sch.	Heidelberg, Germany.
	9	1932	yes	" " " "	Mathematics, Physics, Chem., Geography, History, Latin, Greek,	"Gymnasium" Heidelberg and Berlin- Zehlendorf	-Germany.
...ege	6	1938 Nov. 10	yes	Doctor in Mech. & Indust. Engin'g.	Aerodynamics, Structures, Aircraft Engines. (see also attached transcript)	Institutes of Technology Berlin- Charlottenburg (1 yr.) and Milan	Italy (5 yrs.)
...le or ...tional							

NOTICE All Applicants Showing Vocational Training must be able to furnish Transcript of School record.

...e you ever filed application for employment with this company before? no When? - Where? -

...ve you ever worked for this company before? no When? - Why did you leave? -

PREVIOUS EMPLOYMENT RECORD

NOTICE — Account for all Periods of Unemployment

Name of Employer and Type of Business	Department and Address	Your Position and Duties	Dates by Month and Year	Rate of Pay	Why Did You Leave?
Present or Last: ...eing School of ...ronautics	Oakland, California	In charge of aeron. engineering courses. Appl. Mech., Strength of Materials, Science of Mechanism, Advanced Structures, Basic & Advanced Aerodynamics, Basic Aeron. Meteorology.	Oct. 39 May 42		To complete technical text work under contract for publication and organize vitally needed technical training courses for transoceanic ferry airline.
Next to Last					
Next Previous					
Next Previous: ...iversity of ...lifornia.	Extension Division, Berkeley, California	CPT instruction Meteo. & Nav. Elem. Meteorology	1940 - May 42		
Next Previous: ...l Development ...rporation	120 Liberty St., New York, N.Y.	Experimental development work and design on automatic engine controls for Mr. Fokker's yacht "Q.E.D."	May 39 July 42		Completion of project followed by dissolution of firm.
Next Previous					
Next Previous: ...mposition of technical articles (for example, "Aviation", ...ne and August, 1939) and a technical report to the CAA			Feb. 28, 39 to May 39		
Next Previous: ...avels (France, Italy, England, U.S.)			Nov. 38 to Feb. 39		after conferment of degree on November 10, 1938.
Next Previous: ...rch Division of ...e Auto-Union	Zwickau-Germany	apprentice engineer	Mar. 32 Oct. 32		learned to operate all standard machine tools in tool department, then completed apprenticeship in inspection department and experimental shop, working on rear engine racing cars.
Previous: ...merous brief periods (summer vacations) as apprentice ...gineer in small machine shops and at sea (freighter).			1932 to 1938		
Next Previous					

you ever been discharged? no If so, where and why? -

you ever been in business for yourself? no What kind? -

th of Shop Experience since 193_ Do you read and work from blueprints? yes

Precision instruments with which you are familiar: Micrometers, Calipers, Surface Gauge, Vernier Gauge, Radius Gauge. All.

you hand tools for work desired? yes

EE REFERENCES (Other than Previous Employers and Relatives)

	Business	Address
John _. Thor_	Project Engineer	Vega Aircraft Corp., Burbank, Cal.
Lewin B. Barringer	Glider Specialist, Off. of the Chief of Staff, US Air Corps,	War Dept., Washington, D.C.
. Irwin E. Farington	Coordinator, District 2, Calif.	Selective Serv. H'dqu's, Berkeley, Calif.

any objections to working nights, Saturdays or Sundays. none

nic Ailments or cal Defects? none Do you have a Rupture now? no Have you ever been ruptured? no If so, cured by Surgery or Injections? - When? -

you ever had or Fainting Spells? no Have you ever been vaccinated? yes If so, when and what? Smallpox and ~~tetanus as a child~~

ou wear glasses? no Cause - Is vision corrected with glasses? -

you ever had a severe illness or operation? no If so, when and what? -

received compensation for accident or disability? no If so, give Name of Company -

? - Type of Injury? - Amount Received? -

APPLICANT DOES NOT WRITE BELOW THIS LINE

1 2 3 4	Educ 1 2 3 4	P-EM 1 2 3 4	Att 1 2 3 4	Acct 1 2 3 4	Res't 1 2 3 4
√	C-Tec √	Iden	Eves	Qual √	Accep √
	C-Gen	Sim √	U-Cop	Adapt	Rejt
	C-Ext	Rela	Slow	Inex	Decl
	Voc	Dis	Arg	Atti	Hold
	H-Tec	Unql	Migr	N.R.H.	
	H-Gen	Stud	Youth	D-W-J	
	1234		Unk't	W-MM	
	012			U-Dec	
	345			N.Pr.	
	678			Phy	

Referred by

Recommended by

Supplement mailed

Per instruction of

Supplement received

No.	Date	By
1.	9-4-42	[illegible]
2.		
3.		
4.		

ARKS:

No. ked Citizenship Checked

p Insurance Amount Hospitalization Insurance Plan Photographed and Fingerprinted

ance Beneficiary Relationship

Street and Number City State

Admitted November 21, 1950.

19

PLAINTIFFS' EXHIBIT No. 16

Consolidated Aircraft Corporation

3834

Invention Agreement

Agreement entered into by and between Consolidated Aircraft Corporation (hereinafter called the Company), and Maurice Adolph Garbell (hereinafter called Employee), Witnesseth:

In consideration of the mutual undertakings hereinafter set forth the parties hereto do hereby agree as follows:

1. The Employee agrees:

(a) To disclose promptly in writing to the Company's Patent Department or to such person as the Company may designate, all inventions and improvements heretofore or hereafter made, developed, perfected, devised or conceived by the Employee either solely or in collaboration with others during the Employee's employment by the Company, whether or not during regular working hours, and including a period of one (1) year after termination of employment, relating to aircraft or parts and the manufacture thereof, or relating in any way to aviation or to the business, developments or products of the Company; and if so requested by the Company, to assign, transfer and convey to the Company all right, title and interest in and to all such inventions and improvements;

Plaintiffs' Exhibit No. 16—(Continued)

(b) At the request and expense of the Company, to make, execute and deliver any and all application papers, assignments or instruments, and to perform or cause to be performed such other lawful acts as the Company may deem desirable or necessary in making or prosecuting applications, domestic or foreign, for patents and reissues and extensions thereof, and to assist and cooperate (without expense to him) with the Company or its representatives in any controversy or legal proceedings relating to said inventions and improvements or the patents which may be procured thereon;

(c) To regard and preserve as confidential all information pertaining to the Company's business or that may be obtained by the Employee from specifications, drawings, blue prints, reproductions and other sources, and not to publish or disclose either during the term of employment or subsequent thereto, without the written approval of the Company, such or any other confidential information obtained by the Employee while in the employment of the Company.

2. The Company, if it considers any invention or improvement reported by the Employee pursuant to paragraph 1 hereof to be of substantial value and patentable, will, after completing its investigation in regard thereto, award and pay to the Employee the sum of Ten Dollars ($10.00).

Plaintiffs' Exhibit No. 16—(Continued)

3. The Company, if it elects to acquire any invention or improvement referred to in paragraph 1 hereof, agrees:

(a) To notify the Employee of its election so to do within nine months from the date of the complete disclosure of such invention or improvement to the Company;

(b) To pay all expenses in connection with the preparation and prosecution of patent applications in the United States of America and all foreign countries wherein the Company may desire to obtain patents;

(c) To pay the Employee an additional cash award of Forty Dollars ($40.00) upon execution by Employee of applications for United States letters patent upon such invention or improvement, together with an assignment thereof to the Company;

(d) To pay to the Employee an additional cash award of Fifty Dollars ($50.00) if and when the Company obtains a United States patent on such invention or improvement, it being understood that no such award will be paid to the Employee in connection with the granting of any foreign patent;

(e) To pay to the Employee for each of the Employee's inventions additional compensation consisting of a percentage of any income derived by the Company from any sale of such invention or part thereof, or from any royalties which the Company may collect from licenses

Plaintiffs' Exhibit No. 16—(Continued)

to others for the use of such invention, on a sliding scale, as follows:

Of the first $1,000 or part thereof... 30%
Of the next $1,000 or part thereof....25%
Of any further sums in excess
of $2,000........................ 20%

4. It is understood and agreed that the obligation of the Company to make payments pursuant to paragraph 3(e) hereof shall continue during the life of any patent subject to this agreement notwithstanding termination of the Employee's employment with the Company, and that in the event of the Employee's decease, such payments will be made to his executors, administrators or representatives.

5. It is further understood and agreed that the Company may report any such invention or improvement to Manufacturers Aircraft Association, Inc., either with or without claim for compensation therefor, or sell such invention or improvement, or license the manufacture thereof for such price or royalty as the Company in its sole judgment and discretion shall determine, or if the Company elects so to do, grant royalty-free licenses for the use of such invention, or waive future royalties for a definite or indefinite period of time on any license theretofore issued by the Company on a royalty basis, and that in any of such events, the Employee shall have no claim or claims against the Company,

Plaintiffs' Exhibit No. 16—(Continued)

except to receive under the provisions of paragraph 3(e) hereof the percentages above set forth of such amounts as the Company shall collect through the sale of such invention or improvement or the issuance of licenses to use the same.

6. If the Company shall fail to elect in writing that it desires to prosecute a patent application on any invention or improvement specified in paragraph 1 hereof within nine months following the complete disclosure thereof to the Company, then all rights of the Company in and to such invention or improvement shall revert to the Employee with the exception only that the Company shall have a free shop right with respect thereto.

7. Neither this agreement nor any benefits hereunder are assignable by the Employee, but the terms and provisions hereof shall inure to the benefit of the Company's successors and assigns.

Dated: September 7, 1942.

CONSOLIDATED AIRCRAFT
CORPORATION,
By /s/ H. EUGENE POSEK.

/s/ MAURICE ADOLPH
GARBELL,
Employee.

Witness:

/s/ HILDEGARD H. WALTER.

Form 758A (Pat.)

Admitted November 21, 1950.

PLAINTIFFS' EXHIBIT No. 17

Maurice A. Garbell, D. Sc.
Consulting Engineer
1714 Lake Street
San Francisco 21, California
Telephone Bayview 9186

August 5, 1946.

Consolidated Vultee Aircraft Corporation,
San Diego 12, California.

Attention: Mr. Isaac M. Laddon,
Executive Vice-President.

Gentlemen:

It has come to my attention that you have adopted and are utilizing my well-known method of safety wing design in the manufacture of certain commercial and military flying craft.

I am therefore privileged to extend to you at this time an offer to negotiate a license agreement for your use of the aforesaid method of wing design; application for letters patent on the aforesaid invention was filed by me.

I shall look forward to the pleasure of your early reply.

Yours very truly,

/s/ MAURICE A. GARBELL.

MAG:ef

[Stamped]: Received Aug. 8, 1946.

[Attached Envelope]

[27 cents in cancelled U. S. postage stamps.]

[Post-date]: Registered S.F. 8/5/46.

[Post-date]: San Diego 8/7/46.

[Return address]: Dr. Maurice A. Garbell, 1714 Lake Street, San Francisco 21, Calif.

[Addressee]: Consolidated Vultee Aircraft Corporation, San Diego 12, California. Attention: Mr. Isaac M. Laddon, Executive Vice-President.

[Stamped]: Registered No. 45739. Return Receipt Requested.

Admitted November 21, 1950.

Maurice A. Garbell, D. Sc.
Consulting Engineer
1714 Lake Street
San Francisco 21, California
Telephone Bayview 9186

August 12, 1946.

Registered

Consolidated Vultee Aircraft Corporation,
San Diego 12, California.

Attention: Mr. I. M. Laddon, Exec. Vice-Pres.
Mr. G. T. Gerlach, Patent Director.

Gentlemen:

Your letter of August 9th, 1946, is before me.

May I respectfully refer you to my paper "Effective Control of Stalling Characteristics of Highly Tapered and Swept-Back Wings,'' in the February, 1946, issue of the Journal of the Aeronautical Sciences. This publication states the basic principles underlying my invention concisely, lucidly, and substantially; it also conveys the general scope of my patent application.

I trust that you will find the above-mentioned material helpful in enabling you to evaluate my offer of a license to you.

Yours very truly,

/s/ MAURICE A. GARBELL.

MAG:ef

[Stamped]: Received Aug. 14, 1946.

[Attached Envelope]

[27 cents in cancelled U. S. postage stamps.]

[Post-date]: Registered S.F. 8/12/46.

[Post-date]: San Diego 8/13/46.

[Return address]: Dr. Maurice A. Garbell, 1714 Lake Street, San Francisco 21, Calif.

[Addressee]: Consolidated Vultee Aircraft Corporation, San Diego 12, California. Attention: Mr. Isaac M. Laddon, Executive Vice-President.

[Stamped]: Registered No. 62578. Return Receipt Requested.

PLAINTIFFS' EXHIBIT No. 18

Consolidated Vultee Aircraft Corporation
General Offices
San Diego 12, California

August 9, 1946.

Dr. Maurice A. Garbell,
1714 Lake Street,
San Francisco 21, California.

Dear Sir:

Your letter of August 5th directed to Mr. Laddon has been referred to the writer. Since we are unaware of any method of wing design owned by you and utilized in the design of our airplanes, we are unable to evaluate your offer of a license. If you will let us know in detail the invention you believe we are using, we will be glad to give the matter our prompt consideration.

We will accept a copy of the patent application to which you refer for the purpose of a disclosure, on the basis that in so doing, the disclosure is made to us without obligation based upon any kind of confidential relationship, and that no expressed or implied liability exists except to the extent that the subject matter may later support valid patent claims.

Yours very truly,

CONSOLIDATED VULTEE
AIRCRAFT CORPORATION,

/s/ G. T. GERLACH,
Patent Director.

GTG:mm

[Attached Envelope]

[Post-date]: 8/9/46.

[Cancelled U. S. 3 cent stamp.]

[Return Address]: Patent Department, Consolidated Vultee Aircraft Corporation, General Offices, San Diego 12, California.

[Addressee]: Dr. Maurice A. Garbell, 1714 Lake Street, San Francisco, Calif.

Admitted November 21, 1950.

PLAINTIFFS' EXHIBIT No. 19

Consolidated Vultee Aircraft Corporation
General Offices
San Diego 12, California

August 15, 1946.

Dr. Maurice A. Garbell,
1714 Lake Street,
San Francisco 21, California.

Re: Your letter of August 12, 1946 to Mr. I. M. Laddon and Mr. G. T. Gerlach.

Dear Sir:

On December 19, 1944, during your employment at CVAC, you submitted a copy of your paper "Effective Control of Stalling Characteristics of Highly Tapered and Swept-back Wings" to the Patent Department of this company, as a Disclosure

Plaintiffs' Exhibit No. 19—(Continued)

of Invention under the terms of the CVAC Invention Agreement executed by you on September 7, 1942.

Our investigation of this matter indicated (a) that it did not contain material of a patentable nature, and (b) the stall control techniques set forth in the article were well known and amply disclosed in many prior patents. A copy of our Search Report is attached. In view of this, a decision was reached to inactivate the disclosure from the standpoint of CVAC's filing a patent application, and our file indicates that you were verbally informed of this decision.

Under the CVAC Invention Agreement:

Paragraph 6. "If the Company shall fail to elect in writing that it desires to prosecute a patent application on any invention or improvement specified in paragraph 1 thereof within nine months following the complete disclosure thereof to the Company, then all rights of the Company in and to such invention or improvement shall revert to the Employee with the exception only that the Company shall have a paid-up non-exclusive license with respect thereto."

In view of our opinion that no patentability exists in the matter disclosed in your article; and since this company has retained a non-exclusive license to any claim that might be allowed by the Patent Office under the application that you have apparently

Plaintiffs' Exhibit No. 19—(Continued)

filed, there appears no practical purpose in further discussion of our obtaining rights from you. Therefore, unless you believe there is some angle we have overlooked, we will consider the matter concluded.

Yours very truly,

CONSOLIDATED VULTEE
AIRCRAFT CORPORATION,

/s/ G. T. GERLACH,
Patent Director.

GTG:ff
cc: I. M. Laddon
(Copy)

Search Report

June 26, 1946

Re: Docket No. 1562-2,
Airfoil Design Having
Three Controlled Sections,
Maurice A. Garbell.

Report of Search with respect to the above identified disclosure relating to a design means for effecting control of stalling characteristics particularly of highly tapered and swept back wings in which the wing design is based upon the employment of three controlled sections, one located at the wing root, another at the mid-span section, and the third at the wing tip, each section being connected to that next adjacent by straight lines. The desirable results from this design would be a stalling characteristic for the airfoil in which the stall begins initially

Plaintiffs' Exhibit No. 19—(Continued)

at the mid-span section and spreads progressively and evenly inboard and outboard from that point.

The following references appear to present the closest patented are with respect to the present disclosure:

1,246,010	Burgess	11/ 6/17	244-105xr
1,547,644	Cronstedt	7/28/25	244-35
1,729,970	Soldenhoff	10/ 1/29	244-35
1,792,015	Herrick	2/10/31	244-35
1,817,275	Soldenhoff	8/ 4/31	244-35
1,890,079	Focke	12/ 6/32	244-35
2,165,482	Hovgard	7/11/39	244-13
2,281,272	Davis	4/28/42	244-35
2,298,040	Davis	10/ 8/42	244-35
2,329,814	Andrews	9/21/43	244-35
Br. 20,530/09	Vessey	9/ 8/09	B244-35
Br. 573,314	Armstrong-Whitworth	8/28/43	B244-83

The references Armstrong-Whitworth and Burgess each disclose tapered wings having considerable sweep back and which as appears in Fig. 1 of Armstrong and Fig. 4 of Burgess, at approximately the mid-span position have a break in the wing plan form with the outboard portion having at least a different angle of sweep back. The root, mid-span and outboard sections appear to be connected by straight lines but what these sections are or how they might differ from each other is not set forth. The reference showings of Andrews and Davis (Patent No. 2,298,040) are also illustrative of airfoils in which there is a pronounced change, at least in plan form, at approximately the mid-span station.

Plaintiffs' Exhibit No. 19—(Continued)

The references Cronstedt, Soldenhoff, Herrick and Focke have all been noted as providing examples of airfoils in which the root section, mid-span section and outboard section have been specifically set forth and which are of different profile. In Soldenhoff, (Patent No. 1,729,970) the airfoil arrangement of interest is shown in Figs. 2 and 2b while in Herrick, the figures of interest are designated 5 to 8 inclusive. As far as can be determined from the drawings, the various sections would appear to be connected by straight lines. None of these four references sets up the definite object of predetermining a certain desired stalling characteristic of the wing although it might be that one of these designs might have the inherent characteristic of stalling first at the mid-span station.

It is interesting to consider the potentialities of the reference Focke in this respect. In the reference Hovgard, the object is to provide a means for delaying the stall on an inboard section of the wing so that the wing will have a more uniform stall characteristic over all. To obtain this it provides an inboard wing section having one profile and an outboard section having another profile. The Davis Patent No. 2,281,272 may also be of interest as it teaches that a fluid foil may utilize one sectional profile at one point of the span and other section profiles at other points; in the illustration of Fig. 2 there being apparently a basic section located at the mid-span station and root and tip

Plaintiffs' Exhibit No. 19—(Continued)

sections which represent variations from the basic section. Also noted as of possible general interest is the reference Vessey which shows a circular airfoil having a number of different sectional profiles at radial stations about the circumference of the whole unit.

The search has covered the following field:
Class 244, Aeronautics,

Sub-classes 13, Aircraft, heavier-than-air, airplane sustained,
35, Aircraft sustentation, sustaining airfoils,
Br.35, Aircraft sustentation, sustaining airfoils,
45, Aircraft sustentation sustaining airfoils, arrangement.

[Attached Envelope]

Registered

[32 cents cancelled U. S. postage.]

[Post-date]: San Diego 8/16/46.

[Post-date]: S.F. 8/17/46.

[Return address]: G. T. Gerlach, Consolidated Vultee Aircraft Corporation, General Offices, San Diego 12, California.

[Addressee]: Dr. Maurice A. Garbell, 1714 Lake Street, San Francisco 21, California.

[Stamped]: 735809 Registered. Return Receipt Requested. Fee Paid.

Admitted November 21, 1950.

PLAINTIFFS' EXHIBIT No. 21

Consolidated Vultee Aircraft Corporation
San Diego, California

June 17, 1948

Study of Garbell Patent No. 2,441,758 Filed July 16, 1946 and Issued May 18, 1948 Relative to Non-Tip Stall Wing Developed by CVAC

Reference:

(A) Docket No. 1562-2 Method of Airfoil Selection—M. A. Garbell.

(B) Effective Control of Stalling Characteristics of Highly Tapered and Swept-back Wings, by M. A. Garbell C.V.A.C. Dec. 5, 1944. Paper written for presentation before January 1945 Annual Meeting (Cancelled) of the Institute of the Aeronautical Sciences. Received by Patent Dept. December 20, 1944.

(C) Paper of reference (b) corrected slightly and published in the Journal of the Aeronautical Sciences, February 1946.

Summary

1. The only new items or statements in the Garbell patent relative to references (B) and (C) are:

(a) "Additional control sections over three" is obviously design and not invention.

(b) "Greatest mean line camber at wing tip" is a limitation in all claims which is not necessary to the proper functioning of the subject development.

Plaintiffs' Exhibit No. 21—(Continued)

(c) Curvilinear polygon of maximum lift envelopes the spanwise lift distribution is disclosed by the reference (B) and (C) figures but is not named as such.

(d) Errors in the figures of references (B) and (C) have been corrected to some degree in the Garbell patent.

(e) Rough tangent method of locating third control section is only possible addition of "new matter," but it functions only in some circumstances.

2. Claims 1, 2, 3, 5, 6 and 12 appear to be utilized by the Model 240 wing.

The XP5Y-1 does not utilize any of the claims of the Garbell patent.

3. The principle of stall control of tapered plan form wings as disclosed in the Garbell patent is completely shown by the simple addition of plan form taper to the drawings of Cronstedt patent No. 1,547,644 filed in 1921. Claims 11 and 12 of the Garbell patent read on the drawings of the Cronstedt patent.

4. The teaching of the Garbell patent is not followed in the design of the Model 240 wing. The third control section is at 30.7% semi-span outboard of the root section and the stall starts between the fuselage and the engine nacelle at about 15% semi-span.

Plaintiffs' Exhibit No. 21—(Continued)

Pertinent Points of the Development in Ref. (B) Paper

This paper was so incomplete when submitted as a disclosure by Garbell, that the present writer requested that a complete disclosure as required by the "Invention Agreement" be submitted to the Patent Department before it would be accepted for docketing. The paper while based on empirical studies and research that effectively licks the critical wing tip stalling problem of many years standing, does not disclose how to apply the development in good logical technical form as customary with engineering and scientific papers, but rambles on with the faults of conventional wings and what is desired and accomplished with the use of three control sections.

The pertinent points given by the paper follow:

1. Three controlled airfoil sections.

2. The paper does not discuss the relative types of airfoils at the three control sections, except that the "Conclusion" specifies a typical combination of NACA airfoils as follows:

(a) Root Section NACA 2518—2% mean line camber and 18% thickness ratio.

(b) Wing tip or second control section—NACA 4512—4% mean line camber and 12% thickness ratio.

(c) Third control section—NACA 3515—3% mean line camber and 15% thickness ratio. In

Plaintiffs' Exhibit No. 21—(Continued)

this case the second or tip control section has a larger camber than the third control section.

3. Page 7 and figure 9 describe a wing having a wing tip airfoil with a thickness ratio smaller than the optimum for maximum lift so that the optimum thickness airfoil occurs somewhat inboard of the wing tip.

New Statements (Not New Matter) in Garbell Patent Relative to Ref. (B) Paper

1. Additional Control Sections Over Three

   It is an obvious design improvement to use additional control sections if so required by the wing configuration.

2. Greatest Camber at Wing Tip

   Specification column 7, lines 54 to 61 and more specifically lines 59 and 60 "an airfoil section 3 or 8 having the greatest mean-line camber at the tip." Each of the fifteen claims contains this matter as a limitation and the papers (B) and (C) do not discuss the relative cambers of the mean lines of the three control sections.

3. Curvilinear Polygon

   Specification column 7, lines 56 to 61 "defined by the curvilinear polygon 5 (fig. 2), embodying the combination of an airfoil section 1 or 9 having the smallest mean line camber at the tip, and one or more interjacent controlled sections 2 or 11." Claims 2, 3 and 6 contain this matter as a limitation. The "curvilinear polygon" is not

Plaintiffs' Exhibit No. 21—(Continued)

mentioned in reference (B) but figures 7, 9 and 10 disclose it.

4. Figures 2 and 5 Show Stall at Wrong Location

   In figure 7 of reference (B) and (C) papers as drawn, the stall would start at the point of tangency of the two curves near the wing tip. These papers state that the stall starts in mid-semi-span but they do not show how. In figure 2 of the Garbell patent, the stall would occur simultaneously at the two points of tangency of the curves, with the outer stall being localized and the inner stall spreading more rapidly. Figure 3 (ref. specification col. 5, lines 37 to 50) does not agree with figure 2 since it shows the stall starting a little inboard of mid-semi-span. The specification column 10, lines 9 to 25 and more specifically lines 17 to 20, shows how the stall develops at about mid-semi-span and thus corrects the errors in figures 7, 9 and 10 of references (B) and (C) and figures 2 and 5 of the Garbell patent.

5. Specification column 7, lines 14 to 29 and figure 4 disclose a rough method of locating the third control section. This method apparently has no theoretical basis and when applied to figures 7, 9 and 10 of references (B) and (C) erroneously locates the third control section close to the wing tip. Claims 7, 8, 13 and 14 contain this "method" of locating the third control section. The method

Plaintiffs' Exhibit No. 21—(Continued)

fails to work on Model 240 wing since the third control section is at 30.7% semi-span instead of 60 to 80% by this method.

Utilization of Patent Claims by CVAC Models

1. Model 240 Wing
   Root Section NACA 63,4-120 a=1.0
   Mean line camber=.55% Thickness ratio=20%
   Wing tip section NACA 63,4-515 a=1.0
   Mean line camber=2.75% Thickness ratio=15%
   Third control section NACA 63,4-419 a=1.0
   Located at 30.7% semi-span outboard of root section
   Mean line camber=2.2% Thickness ratio=19%
   The mean line camber of the third control section is larger and the thickness ratio is smaller than a straight line fairing between the root and tip sections.
   Claims 1, 2, 3, 5, 6, and 12 appear to be utilized by the Model 240 wing.

2. XP5Y-1 Wing
   Root section NACA 1420
   Mean line camber=1.0% Thickness ratio=20%
   Wing tip section NACA 4412
   Mean line camber=4.0% Thickness ratio=12%
   Third control section NACA 4417 at 60% semi-span
   Mean line camber=4.0% Thickness ratio=17%
   The mean line camber is constant from the third

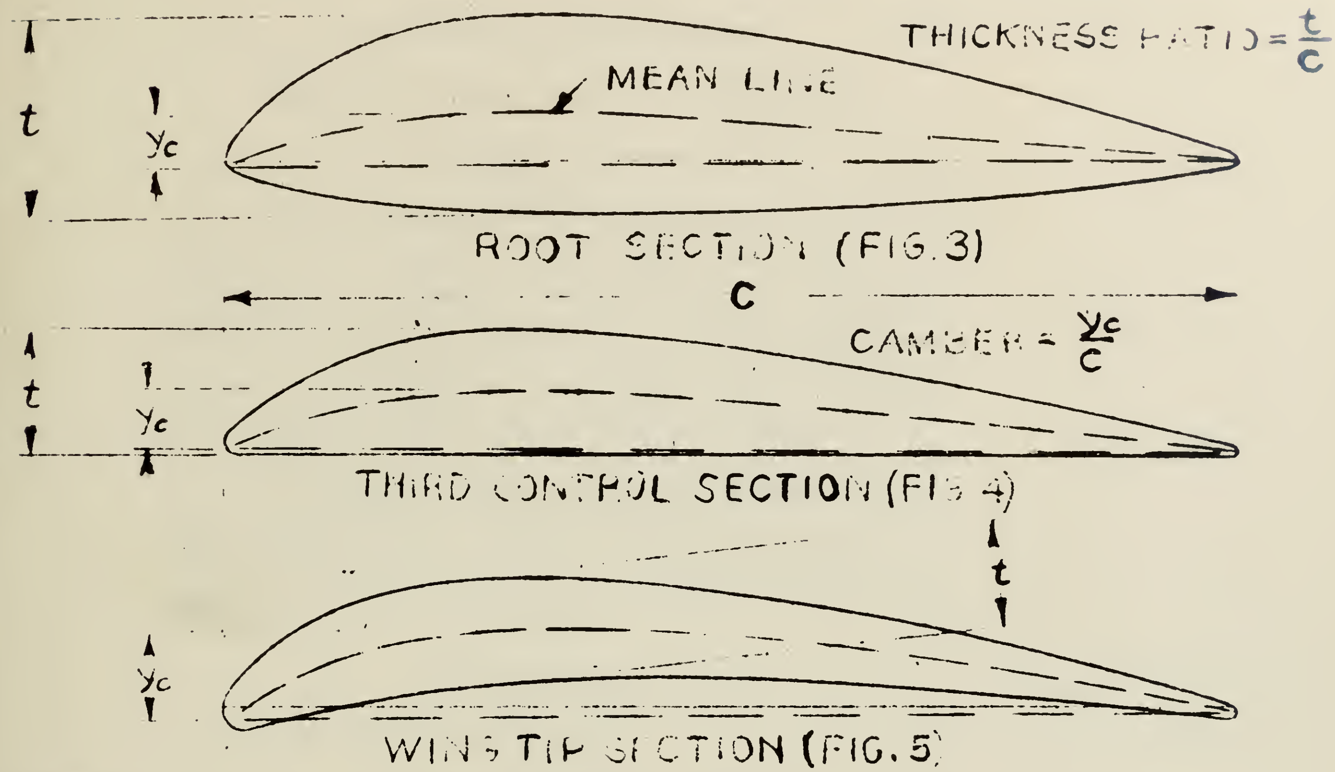
Plaintiffs' Exhibit No. 21—(Continued)

control section to the wing tip. Since each of the fifteen claims contains "the second section with the greatest mean line camber is located at the fluid dynamically effective tip," the XP5Y-1 airplane does not utilize any of the claims of this patent.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
San Diego, California

CRONSTEDT PATENT NO. 1,547,644 (FILED 1921) DRAWINGS

ANTICIPATE GARBELL PATENT



Figures 3, 4 and 5 of the Cronstedt patent are reproduced above. The mean or median line for each section while not shown in the patent has been developed above. The original chord lines are shown lightly while the mean line chord line is shown heavy (dashed). While the Cronstedt patent specification shows no functioning related to the Garbell patent, figures 3, 4 and 5 clearly show airfoil sections which cause the wing to function closely to the teaching of the Garbell patent. The third control section of figure 4 has a mean line camber greater than that of the root section and less than that of the tip section, and a thickness ratio less than that of the root section and greater than that of the tip section, the same as disclosed by the Garbell patent. Tapering the plan form of the Cronstedt wing is the only change Garbell has made, which certainly is not invention.

Claims 11 and 12 of the Garbell patent read on the wing shown by the drawings of the Cronstedt patent.

Plaintiffs' Exhibit No. 21—(Continued)

Concluding Remarks

1. The teaching of the Garbell patent is not followed in the design of the Model 240 wing. The third control section is located at 30.7% semi-span outboard of the root section and the stall starts between the fuselage and the engine nacelle at about 15% semi-span outboard of the root section.

2. It appears that in some wing designs better stall characteristics can be had by the use of a higher mean line camber for the third control section than for the tip section.

D. A. HALL,

/s/ D. A. HALL.

Admitted November 21, 1950.

PLAINTIFFS' EXHIBIT No. 22

Assignment

Whereas, the undersigned, Maurice A. Garbell, Inc., a corporation organized, existing and doing business under and by virtue of the laws of the State of California, is the owner of an invention relating to certain new and useful improvements in "Fluid Foil Lifting Surface," for which application for Letters Patent of the United States was made on July 16, 1946, Serial No. 683815, and for which said invention Letters Patent of the United

Plaintiffs' Exhibit No. 22—(Continued)

States were duly issued to the undersigned on May 18, 1948, in Patent No. 2,441,758; and

Whereas, the undersigned is likewise the owner of two (2) inventions covering certain new and useful improvements in (1) Fluid Dynamic Stabilizer and Damper, and (2) Lifting Surface, for which applications have been made for Letters Patent of the United States as follows:

(1) Fluid Dynamic Stabilizer and Damper—Serial No. 683814, dated July 16, 1946.

(2) Lifting Surface—Serial No. 697281, dated Sept. 16, 1946.

and which applications are now pending; and

Whereas, Garbell Research Foundation, a general non-profit corporation organized, existing and doing business under and by virtue of the laws of the State of California, having its principal office located in the City and County of San Francisco, State aforesaid, and being formed for the purposes of scientific research for the benefit of mankind, is desirous of acquiring an undivided three-fourths (¾ths) part of the entire right, title and interest in and to said inventions, and each of them, in and through the United States of America, its territories and all countries foreign thereto, and in and to the said Letters Patent, and in and to the said applications for Letters Patent, and in and to any and all Letters Patent of the United States of America and countries foreign thereto which have been or may be granted thereon;

Plaintiffs' Exhibit No. 22—(Continued)

Now Therefore, for and in consideration of the sum of One Dollar ($1.00) and other good and valuable consideration, receipt whereof is hereby acknowledged, the undersigned, Maurice A. Garbell, Inc., a California corporation, by these presents does sell, assign and transfer unto the said Garbell Research Foundation, a corporation, its successors and assigns, the undivided three-fourths (¾ths) part of the entire right, title and interest in and to said inventions, and each of them, in and throughout the United States of America, its territories and all countries foreign thereto, and in and to said Letters Patent No. 2441758, and in and to said application for Letters Patent, Serial No. 683814 and Serial No. 697281, and any and all Letters Patent and extensions thereof of the United States of America and all countries foreign thereto which have been or may be granted on said inventions, or each of them, or any part thereof, or on said applications or any divisional continuing renewal, reissue or other applications based in whole or in part thereon, or based upon said inventions;

To Be Held and Enjoyed by the said Garbell Research Foundation, a corporation, its successors and assigns, for its or their interest, and its or their own use and behoof, and for its or their legal representatives to the full ends of the terms for which said Letters Patent, or any of them, have been granted or may be granted, including the right and any and all rights to commence, maintain and prose-

Plaintiffs' Exhibit No. 22—(Continued)

cute any action and all actions for injunctive or other relief against any infringement thereof, and to recover any profits and/or damages arising out of the infringement of said inventions and/or Letters Patent, or either or any of them, as fully and entirely as the same would have been held and enjoyed by the undersigned had this assignment not been made; and

The undersigned does hereby authorize and request the Commissioner of Patents of the United States of America to issue any and all Letters Patent of the United States of America which may be granted upon the said applications above referred to, or any of them, or upon said inventions or any part thereof to the undersigned and the said Garbell Research Foundation, a corporation, as their interests appear in accordance with the terms hereof; and

The undersigned does agree for itself, its successors and assigns, to execute without further consideration any further or additional legal documents, and any further or additional assignments and any reissue, renewal or other applications for Letters Patent that may be deemed necessary by the assignee herein named fully to secure to the said assignee its interest, as aforesaid, in and to said inventions, or any part thereof, and in and to several Letters Patent, or any of them; and

The undersigned does hereby covenant for itself and its legal representatives, and does hereby agree

Plaintiffs' Exhibit No. 22—(Continued)

with the said Garbell Research Foundation, a corporation, its successors and assigns, that the undersigned has granted no license to make, use or sell the said inventions, or either of them, or any part thereof; that prior to the execution of this assignment, its right, title and interest in said inventions, and each of them, had not been encumbered; that it then had and does now have good right and title to the same, and that it has not executed nor will it hereafter execute any instrument in conflict therewith.

In Witness Whereof, the undersigned has hereunto set its hand and seal this 15th day of September, 1949.

[Seal] MAURICE A. GARBELL, INC.

By /s/ ETTA FEITELBERG,
Vice-President and Treasurer.

/s/ LOLA J. FEITELBERG,
Secretary.

State of California,
City and County of San Francisco—ss.

On the 15th day of September, 1949, before me, Theodore A. Kolb, Notary Public in and for the City and County of San Francisco, State of California, personally appeared Etta Feitelberg and Lola J. Feitelberg, known to me to be the Vice-President-Treasurer and Secretary respectively of

Plaintiffs' Exhibit No. 22—(Continued)

the corporation that executed the within instrument, and acknowledged to me that such corporation executed the same.

[Seal] /s/ THEODORE A. KOLB,
Notary Public in and for
Said County and State.

My Commission Expires January 5, 1953.

Recorded, U. S. Patent Office Sept. 20, 1949. Liber N221, Page 123.

Assignment

Whereas, I, Maurice A. Garbell, of the City and County of San Francisco, State of California, have invented certain new and useful improvements in (1) Fluid Dynamic Stabilizer and Damper, (2) Fluid Foil Lifting Surface, and (3) Lifting Surface, for which I have made application for Letters Patent of the United States as follows:

(1) Fluid Dynamic Stabilizer and Damper—Serial No. 683,814, dated July 16, 1946

(2) Fluid Foil Lifting Surface—Serial No. 683,815, dated July 16, 1946

(3) Lifting Surface—Serial No. 697,281, dated Sept. 16, 1946

and which applications are now pending; and

Whereas, Maurice A. Garbell, Inc., a California corporation, with its principal place of business in

Plaintiffs' Exhibit No. 22—(Continued)

the City and County of San Francisco, State of California, is desirous of acquiring the entire right, title and interest in and to said inventions in and throughout the United States of America, its territories, and all countries foreign thereto, and in and to the said applications for Letters Patent, and in and to any and all Letters Patent of the United States of America and countries foreign thereto, which have been or may be granted thereon:

Now, Therefore, for and in consideration of the sum of One Dollar ($1.00) and other good and valuable consideration, receipt whereof is hereby acknowledged, I, Maurice A. Garbell, do hereby sell, assign and transfer unto the said Maurice A. Garbell, Inc., its successors and assigns, the entire right, title and interest in and throughout the United States of America, its territories, and all countries foreign thereto, in and to said inventions, said applications for Letters Patent, Serial No. 683,814, 683,815 and 697,281, respectively, and any and all Letters Patent and extensions thereof, of the United States of America and countries foreign thereto, which have been or may be granted on said inventions or any part thereof, or on said applications or any divisional, continuing, renewal, reissue, or other applications based in whole or in part thereon, or based upon said inventions:

To be held and enjoyed by the said Maurice A. Garbell, Inc., its successors and assigns, for its or their interest, for its or their own use and behoof,

Plaintiffs' Exhibit No. 22—(Continued)

and for its or their legal representatives, to the full ends of the terms for which said Letters Patent, or any of them, have been granted or may be granted, as fully and entirely as the same would have been held and enjoyed by me had this assignment and sale not been made; and

I do hereby authorize and request the Commissioner of Patents of the United States of America to issue any and all Letters Patent of the United States of America which may be granted upon the said applications above referred to, or any of them, or upon said inventions or any part thereof, to the said Maurice A. Garbell, Inc.; and

I do hereby agree, for myself and for my heirs, executors and administrators, to execute without further consideration, any further legal documents and any further assignments, and any reissue, renewal or other applications for Letters Patent that may be deemed necessary by the assignee herein named, fully to secure to the said assignee its interest as aforesaid in and to said inventions or any part thereof, and in and to several Letters Patent, or any of them.

And I do hereby covenant for myself and my legal representatives and agree with Maurice A. Garbell, Inc., its successors and assigns, that I have granted no license to make, use or sell the said inventions, that prior to the execution of this deed my right, title and interest in said inventions had not been encumbered, that I then had good right and

Plaintiffs' Exhibit No. 22—(Continued)

title to the same, and that I have not executed and will not execute any instrument in conflict therewith.

In Witness Whereof, I have hereunto set my hand and seal this 16th day of April, 1948.

/s/ MAURICE A. GARBELL.

State of California,
City and County of San Francisco—ss.

On this 16th day of April, 1948, before me personally appeared Maurice A. Garbell, to me known, and known to me to be the person described in and who executed the foregoing Assignment, and he duly acknowledged to me that he executed the same for the use and purposes therein mentioned.

/s/ VIOLET NEUENBURG,
Notary Public.

Notary Public in and for the City and County of San Francisco, State of California.

My Commission expires January 3, 1951.

Recorded U. S. Patent Office April 20, 1948. Liber S215, Page 545.

Admitted November 22, 1950.

PLAINTIFFS' EXHIBIT No. 25

Intra-Company Correspondence

Consolidated Vultee Aircraft Corporation
General Offices: San Diego, California

Aero Memo #604
Date: March 2, 1945

To: Mr. T. P. Hall

From: Mr. M. A. Garbell

Subject: Alternate Wing for the Model 37 Airplane

Reference: (a) Report entitled: "A Study of Various Alternate Designs to Improve the Stalling Characteristics of the Model 37 Airplane."

Enclosure: (A) Report of reference (a).

The enclosed report presents the results of a study that is intended to correct the now unfavorable stalling characteristics of the XB-36 wing. The object of the study is the attainment of good stalling characteristics, with full lateral control through the stall and adequate stall warning, but at no additional drag penalty over the present XB-36 wing.

The study was undertaken in anticipation of the increasingly stringent stability and control requirements for the commercial 320,000-lb. version of the Model 37 airplane, and in view of the structural redesign required for the recently increased gross weight of that airplane.

The "tri-section wing" principle which has been successfully applied to the Tailless design, the executive transport, and the XB-46 design, yields several satisfactory wings.

None of the proposals requires a change in plan form nor in wing-root thickness, but the airfoils have been altered considerably. The following synopsis correlates the present wing and the two most promising proposals:

	Station			
Wing	Root	60% Span	Tip	
Original XB-36 Wing	63,4-422	63,4-(.43)20.6	63,4-517	Airfoil Section
	Basis	0.25°	0.81°	Aerodynamic Washout
Proposal #6	63,4-222	65,3-518	65,3-514	Airfoil Section
(preferred)	Basis	0.42°	0.42°	Aerodynamic Washout
Proposal #2	63,4-222	63,4-518	63,4-514	Airfoil Section
(2nd choice)	Basis	0.49°	0.49°	Aerodynamic Washout

No attempt has been made in the enclosed report to evaluate, in the light of the CAB requirements on proper stall characteristics, the advantages gained by eliminating a vicious wing-tip stall and increasing the maximum wing lift coefficient by approximately 0.1, because these advantages are self-evident.

It is suggested that an alternate wing be built for the 1/26-scale wind tunnel model of the Model 37 airplane. This model should be tested in one of our forthcoming Galcit or M.I.T. test periods, whenever the opportunity for one day's testing arises. The brief test will provide preliminary information on the improved alternate wing, should further wind-tunnel and flight tests confirm the unfavorable stall characteristics of the XB-36 wing.[1]

/s/ M. A. GARBELL.

MAG:jm
cc: Dev. Engr. File

[[1]Longhand note referring to this paragraph]: Not at this time. /s/ P. T. H.

Admitted November 22, 1950.

Consolidated Vultee Aircraft Corporation
San Diego, California

Date: March 3, 1945.

Memo
R. L. Bayless

To: Mr. T. P. Hall.

This study was done over a period of time as other work permitted.

The proposed changes are based on airfoil data and theoretical analyses which were not available at the time the XB-36 wing was established.

R. L. BAYLESS.
/s/ B.

[Marginal note]: Miss C pl bring up on my return plus 2 days.

/s/ T. P. H.

PLAINTIFFS' EXHIBIT No. 26

Intra-Company Correspondence
Consolidated Vultee Aircraft Corporation
General Offices . . San Diego, California

Date: April 24, 1945.

To: M. A. Garbell, Development Engineering, San Diego.
From: Patent Department.
Subject: Docket 1128-R
Hydrofoil
Docket 1129-R
High Speed Air Intake.

Dear Mr. Garbell:

We have been notified by our Accounting Department that two checks each in the sum of ten dollars ($10) have been forwarded to you.

This is in accordance with paragraphs 2 and 3(a) of the CVAC Invention Agreement and is notification to you of the election of the company to accept the inventions involved.

/s/ WALTER J. JASON.

WJJ:jn

Plaintiffs' Exhibit No. 26—(Continued)

Intra-Company Correspondence
Consolidated Vultee Aircraft Corporation
General Offices . . San Diego, California

Date: November 20, 1944.

To: M. A. Garbell—661-379745—San Diego
Development Engineering.
From: Patent Department.
Subject: Docket 1129-P
High Speed Air Intake
M. A. Garbell.

We have received your disclosure on the High Speed Air Intake which has been assigned Docket No. 1129-P. You will be advised of the results of our investigation as soon as possible.

If you should have any further inquiries, suggestions or additions, please contact Mr. Rolf Evers. Division Patent Engineer.

/s/ GORDON GRENOLDS,
Patent Department.

GG/abh
cc: J. L. Kelley
R. Evers

Plaintiffs' Exhibit No. 26—(Continued)

Intra-Company Correspondence
Consolidated Vultee Aircraft Corporation
General Offices .. San Diego, California

Date: December 18, 1944.

To: Mr. Rolf Evers, Patent Engineer.
From: Mr. M. A. Garbell.
Subject: Docket 1129-P—High-speed Air Intake.
Reference: (a) Mr. Walter J. Jason's Memo of December 9, 1944.

A study of the patents enclosed with the referenced memo has been completed and the following conclusions have been reached:

Wagenseil 1,376,178

This patent refers to the now conventional air intake. The undesirable airflow characteristics of this and similar intakes has been already discussed in the subject disclosure. The bodies located in the intake and exhaust of the duct, respectively, shown in Fig. 6 of Mr. Wagenseil's patent application, are merely control organs (valves). The valves are evidently not intended to provide any favorable pressure distribution for a more efficient air inflow, free from airflow separation at moderate and large angles of attack.

Newcombe 2,353,966

The small airfoil shaped body located in the leading-edge duct of radiator 25 in Fig. 1 of Mr. Newcombe's patent application does not have an appropriate shape to prevent separation at the duct lips. It is totally contained in the basic airfoil shape,

Plaintiffs' Exhibit No. 26—(Continued)

where as the subject invention utilizes the aerodynamic pressure distribution and circulation around a protruding airfoil to convey the air more efficiently into the air intake duct. Mr. Newcombe's patent does not contain any claim regarding the aerodynamic action of such an airfoil.

Townend 1,813,645

This patent describes an annular cowling about a circular body from which individual cylinders are protruding into the airstream. The device, known as the "Townend ring" provides an external fairing of an aerodynamically rough body, rather than a guiding vane of an aerodynamically critical duct.

Vance 2,136,403

This arrangement, intended to achieve a large angle-of-attack range for air intake ducts, attains its goal at a substantial sacrifice in efficiency, because only one of the two branch ducts is fully effective at any large angle of attack (see lines 32 to 35 in the right-hand column of page 3 of the claim).

Dornier 2,249,984

The guide plate 4, shown in this claim, is mainly intended to provide a fairly efficient intake shape when the duct is only half extended. The guide plate is not properly shaped to produce the aerodynamic pressure distribution and circulation required to prevent airflow separation aft of the intake lips at moderate and large angles of attack. The guide plate is fully contained in the duct.

Plaintiffs' Exhibit No. 26—(Continued)

Griswold 2,348,253

The thermal exchange elements 111 (Figs. 9, 10, 11, and 11a), 227 (Fig. 20), and 248 (Fig. 21), fully contained in the duct and located well aft of the air intake, exert no aerodynamic action other than the thermodynamic transfer of energy from the radiator into the airstream.

Conclusion

It is apparent that none of the patents enclosed with the reference memo evidences any of the important aerodynamic features of the subject disclosure. The guide vanes or plates shown in some of these patents are not aerodynamically integral parts of the intake ducts.

No claim is contained in any of the aforementioned inventions that a high-speed air intake may include a properly designed leading-edge airfoil to prevent intake-lip separation while retaining full duct efficiency throughout an ample range of angles of attack.

It is suggested that the principle employed in the subject invention is of sufficient generality to warrant ample patent protection.

The air-intake design proposed in the subject disclosure will be tested in a forthcoming wind-tunnel test. It is believed that patent protection should be secured prior to the wind-tunnel test in order to avoid difficulties which may arise as a consequence of manipulation of the duct by other than CVAC personnel.

M. A. GARBELL.

MAG:ph

Plaintiffs' Exhibit No. 26—(Continued)

High Speed Air Intake

M. A. Garbell (661-379745)—Inventor

This invention relates to aircraft and particularly to aircraft having air intake openings or scoops in the leading edges of their wings or nacelles.

Airplanes are designed with air intake openings in the leading edges of their wings, and it has been found that when such airplanes are flown in their normal angle of attack the air will be effectively rammed directly into the intake openings. When the angle of attack is increased, however, the air instead of being forced directly into the opening with uniform pressure will flow across the lower edge of the opening at an angle thereto. For example, when the airplane is flown with a normal angle of attack the air will be rammed into the intake opening or scoop in the direction indicated by the arrow in Figure 1 of the drawings. When the attack angle is increased as shown in Figure 2, the air will enter the intake opening in the direction indicated by the arrow in this view. When this latter condition exists the air will tend to separate within the opening at the rear of its lower lip, causing turbulent flow which reduces the ram recovery and hence the pressure drop available for optimum volumetric flow of the air used for oil cooler and intercooler intakes and other purposes.

To overcome this condition the inventor has devised means, in the form of an aerodynamic body arranged within the opening or scoop, and adapted to direct the flow of air into the opening in such a

Plaintiffs' Exhibit No. 26—(Continued)

way that separation or turbulence is prevented, a more appropriate pressure distribution obtained to achieve efficient diffusion, and the required flow of air through the ducts produced with the least loss in ram efficiency.

Figure 3 shows the leading edge of an airplane wing 2 having an elongate opening or scoop 3 for receiving air which is transmitted through a duct to the carburetor or supercharger. In accordance with this invention, the opening 3 is made somewhat wider than ordinary air scoops and extending across the opening from end to end is an intake vane 5. Figure 4 is a cross section on line 4—4 of Figure 3 and shows the intake vane 5 as of aerodynamic shape capable of producing favorable pressure distribution. The aerodynamic body or intake vane 5 is used for the purpose of directing the flow of air into the scoop 3 in such a way that separation or turbulence is avoided. As shown in Figure 3, when the airplane is flown at its normal angle of attack the air will flow across the aerodynamic surface of the body 5 as shown by the arrows to effectively distribute the pressure and properly supply the air ducts. When the angle of attack is increased as shown in Figure 5 the air will be rammed into the scoop 3 in the manner indicated by the arrows in this view. Through the arrangement and shape of the opening and aerodynamic body the pressure of the air passing into the air duct is properly distributed, and the air will thus flow at a high velocity without the occurrence of separation or turbulence adjacent the edges or lips of the air

Plaintiffs' Exhibit No. 26—(Continued)

scoop. While the opening 3 is shown as substantially rectangular in outline, it will be understood that it may assume other shapes, and in this case the aerodynamic body would be of corresponding cross sectional shape.

Date: November 17, 1944.

/s/ MAURICE A. GARBELL,
Inventor.

Date: November 17, 1944.

/s/ W. J. STEVENSON,
Witness.

PLAINTIFFS' EXHIBIT No. 27

Intra-Company Correspondence
Consolidated Vultee Aircraft Corporation
General Offices . . San Diego, California

Date: November 20, 1944.

To: M. A. Garbell—661-379745—San Diego
Development Engineering.
From: Patent Department
Subject: Docket 1128-R
Hydrofoil

Reference: M. A. Garbell.

We have received your disclosure on the Hydrofoil which has been assigned Docket No. 1128-R. You will be advised of the results of our investigation as soon as possible.

If you should have any further inquiries, suggestions or additions, please contact Mr. Rolf Evers, Division Patent Engineer.

/s/ GORDON GRENOLDS,
Patent Department.

GG/abh
cc: R. Evers
J. L. Kelley

Plaintiffs' Exhibit No. 27—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices . . San Diego, California

19 December, 1944.

Mr. Rolf Evers, Patent Engineer.
Mr. M. A. Garbell.
Docket 1128-R—Hydrofoil Arrangement.
Mr. Walter J. Jason's Memo of December 14, 1944.

The patents enclosed with the referenced memo have been studied and the following conclusions have been reached:

Diehl 2,255,046

The writer is in substantial agreement with Mr. Jason's statement, with one important exception. The subject invention relates to an airplane in which the hydrofoils contribute little, if any, static buoyancy. By far the greatest part of the static buoyancy is contributed by the fuselage-hull. Mr. Diehl's invention by contrast, refers to buoyant floats.

Brush 2,073,864
Dyer 1,108,891
Kemp 1,728,937
and others.

These patents propose merely the use of hydrofoils for hydrodynamic lift instead of floats and hulls for static buoyancy. Hydrofoil arrangements of the types proposed in these patents are unsatisfactory, because the hydrofoils are unable to "break" through the water surface owing to cavitation.

Plaintiffs' Exhibit No. 27—(Continued)

It is the express purpose of the subject invention to overcome this serious deficiency of the older hydrofoil arrangements by means of the high trim angle of the main fuselage-hull.

The high angle of attack shown in Fig. 1 of Dyer's patent claim is not the trim angle of the hull, but merely serves to illustrate a typical take-off attitude of the craft.

Parker 2,347,841

This invention refers to retractable hull steps (not spoilers). There is no direct relation between the subject disclosure and Parker's patent. Such retractable steps have not evidenced the drag reduction anticipated by their inventor.

Additional Remarks on the Subject Disclosure

It is contended that the subject disclosure covers a patentable field of considerable amplitude.

No immediate laboratory tests are contemplated, nor are they believed to be required to demonstrate the patentability of the fundamental principle covered by the disclosure. Airplane designs varying in many secondary features may be developed to accomplish the fundamental intent of the disclosure. It may also be argued that it may not be opportune, in the interest of complete protection for the Company, to have designs employing the principle of the subject invention tested in Government or University owned Research Laboratories prior to filing a patent. It is therefore recommended that patent protection commensurate with the manifest merit of

Plaintiffs' Exhibit No. 27—(Continued)

the subject disclosure be secured before tests of any specific design are initiated.

M. A. GARBELL.

MAG:lm.

Hydrofoil Arrangement for Airplanes

M. A. Garbell (661-379745)—Inventor

This invention relates to aircraft and particularly to an improved seaplane having substantially the same aerodynamic characteristics as a land plane. Specifically, this invention relates to an improved hydrofoil installation on fuselages with high trim angles capable of overcoming the critical sub-surface cavitation period which, heretofore, has presented a serious obstacle to the emergence of hydrofoils.

One object of this invention is to provide an aircraft of conventional type with hydrofoils of appropriate contour mounted rigidly or retractably on the fuselage and/or wings in the approximate location of the ordinary tricycle landing gear.

Another object is to provide an aircraft of this type which is designed to trim at a high angle of trim when taxiing on the surface of the water, and also having one or more spoilers attached to the bottom of the fuselage afterbody.

Another object is to provide an aircraft of this type in which the hydrofoils are adapted to emerge from the water due to the high trim angle of the fuselage, this movement being partly or totally independent of the dynamic lift of the hydrofoils.

Another object is to provide an aircraft in which the spoilers, arranged in the lower portion of the

Plaintiffs' Exhibit No. 27—(Continued)

fuselage afterbody, permit the ship to plane (float dynamically) on two main hydrofoils and auxiliary hydrofoil.

Another object is to provide an aircraft which is adapted to land on the hydrofoils and thereafter settle on its fuselage which forms the hull of the ship.

In the accompanying drawings:

Figure 1 shows a conventional type airplane equipped with hydrofoils and spoilers with the ship shown floating on its fuselage-hull;

Figure 2 shows the ship taxiing at the high trim angle of the fuselage-hull and the spoilers operated to break up the suction between the hull and water in order to permit the transition to hydrodynamic planing on the hydrofoils at a reduced trim angle; and

Figure 3 shows the ship planing on the main and auxiliary hydrofoils just prior to take-off of the ship from the water.

The seaplane herein shown comprises a fuselage 2 of a shape similar to those of conventional airplanes and constituting the hull. The ship may have high wings 3 and engines 4 mounted on the wings to position the propellers 5 (or other propulsion devices) high above the free water surface. Projecting downwardly from the nose of the fuselage 2 in the approximate location of the usual nosewheel is an auxiliary hydrofoil 7 which, as shown in the drawings, is of appropriate shape to produce

Plaintiffs' Exhibit No. 27—(Continued)

high lift and low drag. This hydrofoil may be supported in suitable manner. Below the wings 3 are main hydrofoils 8, also of appropriate contour. These hydrofoils may be suspended from the sides of the fuselage-hull 2 as shown or from the under surface of the wings 3. Arranged in the aft portion of the fuselage are retractable spoilers 10.

Assuming that the fuselage-hull 2 of the ship is floating on the surface of the water as shown in Figure 1 with the engines running, when it is desired to take off from the water the thrust of the propulsion devices 5 is increased, and the ship will move forwardly. Because of the high fuselage trim angle, as the ship gains speed, the hydrofoils will climb upwardly with the auxiliary hydrofoil 7 finally emerging from the water and the main hydrofoils 8 planing along the surface of the water as shown in Figure 2. At this juncture the aft portion of the fuselage-hull 2 will be in contact with the surface of the water and to reduce the fuselage trim angle the spoilers 10 are lowered as shown in Figure 2. The spoilers 10 form, in effect, a step similar to that usually provided in the bottom of conventional seaplane hulls so that the suction between the aft section of the fuselage and the water is quickly overcome and the ship thus permitted to plane or float dynamically on the main and auxiliary hydrofoils as shown in Figure 3. The seaplane is thus free to plane on the surface of the water, and as its forward motion is increased to the necessary degree, the craft will take off from the water.

Plaintiffs' Exhibit No. 27—(Continued)

Because of the shape of the hydrofoils the resistance or drag imposed thereby will be reduced to a minimum, and the craft may be flown in a manner similar to conventional airplanes.

When it is desired to land on the water the ship is brought down in such a manner that the hydrofoils 7 and 8 will plane along the surface of the water, and by gradually reducing the speed of the ship and trimming the elevators and other control surfaces the hydrofoils will submerge and the fuselage-hull 2 finally settle on the surface of the water as shown in Figure 1.

It will be observed from the foregoing that the present invention provides a seaplane having a hull (fuselage) and planing surfaces (hydrofoils) of desirable aerodynamic and hydrodynamic shapes, thereby avoiding the use of large, heavy and drag-producing hulls now used in seaplanes. In addition, the high fuselage trim angle acts to overcome the critical sub-surface cavitation of the hydrofoils, the spoilers permitting the airplane subsequently to continue planing on the hydrofoils, and the ship will be able to take off from the water with minimum travel.

Date: November 17, 1944.

/s/ MAURICE A. GARBELL,
Inventor.

Date: November 17, 1944.

/s/ W. J. STEVENSON,
Witness.

PLAINTIFF'S EXHIBIT NO. 28

Admitted November 22, 1950.

Dec. 27, 1949 H. A. SUTTON ET AL 2,492,245

AIRCRAFT CONTROL MEANS

Filed July 25, 1945 2 Sheets-Sheet 1

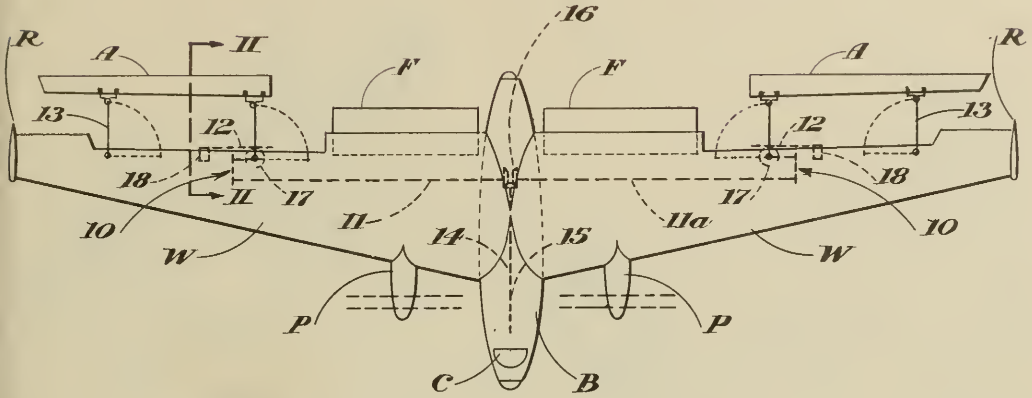


Fig. 1

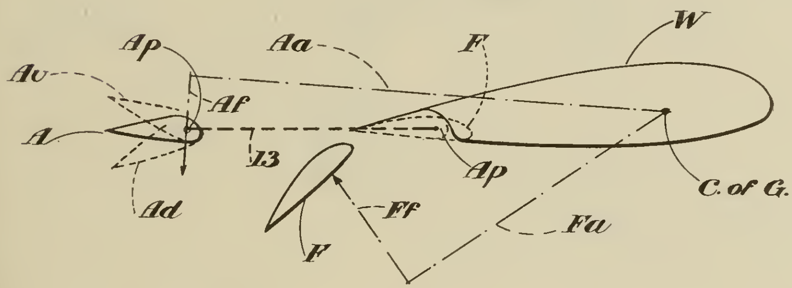


Fig. 2

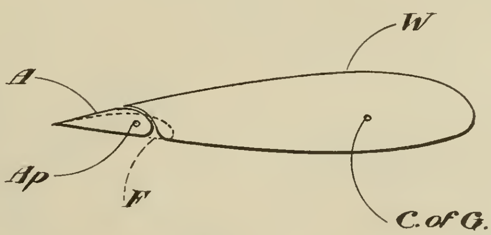


Fig. 3

H. A. Sutton INVENTOR.
and Rolf Evers
BY James M. Clark
Their Patent Attorney

Dec. 27, 1949 H. A. SUTTON ET AL 2,492,245

AIRCRAFT CONTROL MEANS

Filed July 25, 1945 2 Sheets-Sheet 2

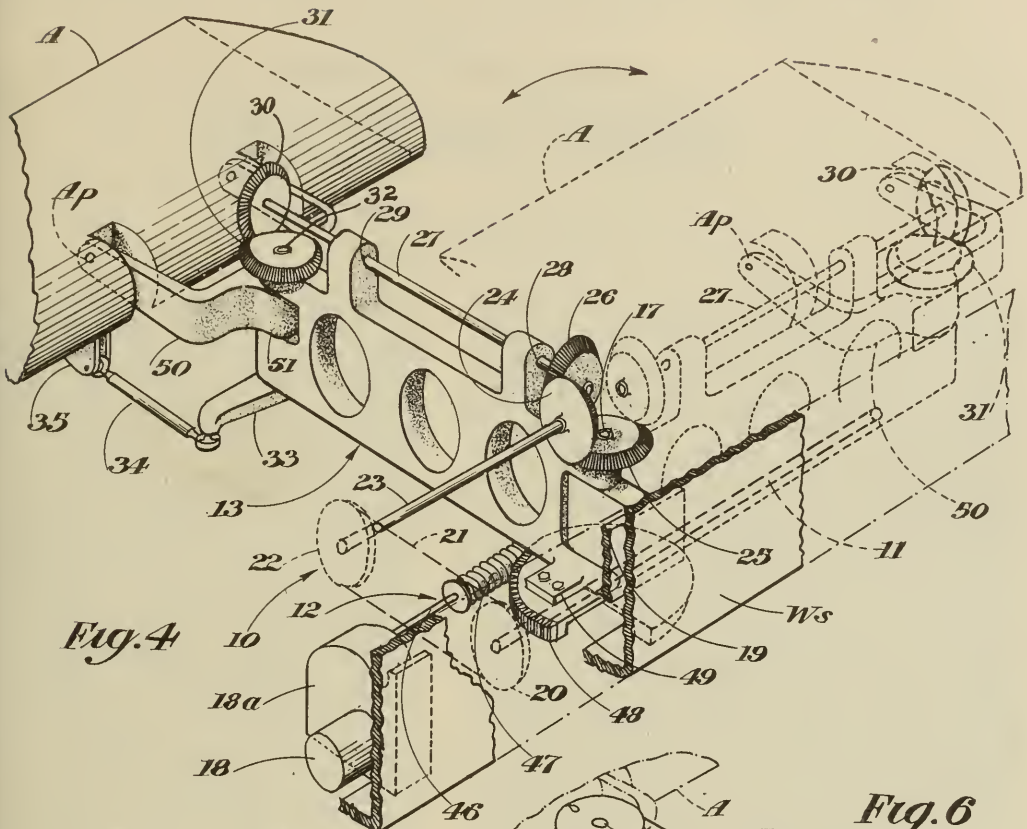


Fig.4

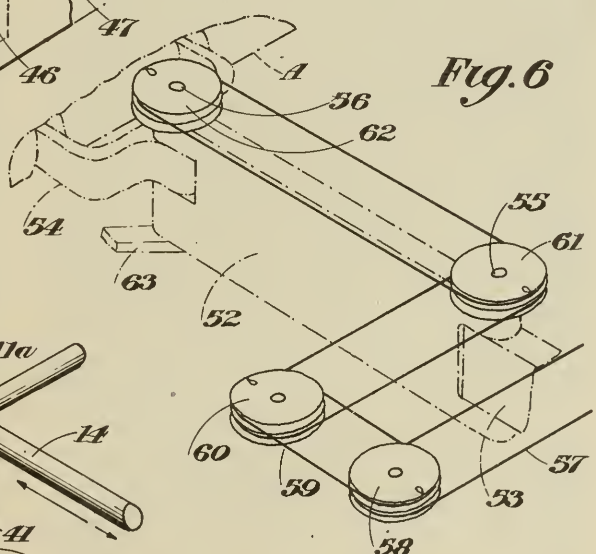


Fig.6

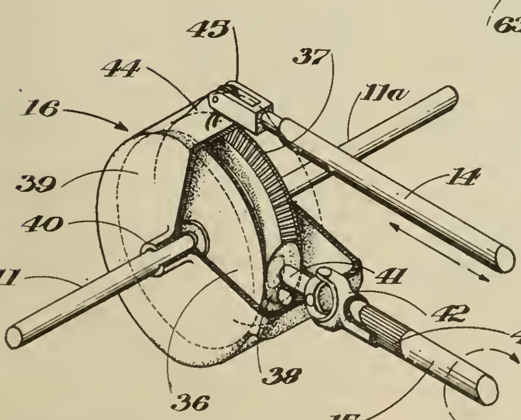


Fig.5

H.A.Sutton INVENTORS
and Rolf Evers
BY James M. Clark
Their Patent Attorney

nted Dec. 27, 1949

2,492,245

UNITED STATES PATENT OFFICE

2,492,245

AIRCRAFT CONTROL MEANS

Harry A. Sutton, Baltimore, Md., and Rolf Evers, Coronado, Calif., assignors to Consolidated Vultee Aircraft Corporation, a corporation of Delaware

Application July 25, 1945, Serial No. 606,914

3 Claims. (Cl. 244—13)

1

present invention relates to the control craft and like vehicles, and is more par- ly directed to extensible control surfaces d for both longitudinal and lateral control. use of high lift flaps for take-off and land- rposes has produced decided aerodynamic tages, particularly in the operation of large ft. The use of certain types of such flaps, er, presents a number of problems par- ly from their inherent disadvantage of g a relatively large rearward shift in the of lift of the wing when the flap is ex- rearwardly. In aircraft of the conven- type having rearwardly disposed horizontal rfaces, this disturbance in the location of nter of lift is readily accommodated by ing a negative lift or downward force by rizontal tail surfaces. In the conventional nage type airplane the flaps usually pro- down-wash effect which acting upon the zer tends to counterbalance the diving t and thereby produce a stable condition. egative lift in the tail surfaces, however, o the load, or to the lift to be developed main sustaining surface, and to this ex- has been found objectionable and to de- rom the aerodynamic efficiency and load- aracteristics of the airplane.

mpts have been made in the prior art to me these disadvantages by the provision iliary lifting surfaces located forwardly espect to the center of gravity of the air- or the center of pressure of the wing in that this auxiliary lift assist the lift of the sustaining surface, rather than to add un- its load.

il-less, or flying wing, types of aircraft the certain type flaps have presented problems are not readily solved as by taking advan- f the use of a conventional tail surface, and selage projection forward of the wing's g edge in tail-less models is not always s to support a forwardly disposed auxiliary surface. Several efforts have been made l-less type airplanes to provide suitable for balancing the diving moments created use of these high lift flaps, but such prior have either been relatively unsuccessful, esulted in materially complicating the de- f the control system or have been found onable for other reasons.

present invention relates to an improved l means for providing a balancing force to ract the diving moment produced in air- provided with flaps and is particularly

2

adapted to the balancing of these diving moments and the provision of longitudinal control and stability in tail-less or flying-wing types of aircraft. The improved surface comprising the present invention consists essentially of a rearwardly and outwardly extensible control surface which is operable in both its retracted and extended, as well as all of its intermediate, positions—both differentially or simultaneously opposite for use as an aileron in providing lateral control, and simultaneously in the same direction, either upwardly or downwardly, for use as an elevator to obtain longitudinal control. The invention further consists in novel actuating mechanism by means of which the control surface is extended from its position at the trailing edge of the main sustaining surface and by which it is concurrently or differentially controlled at the will of the pilot.

It is accordingly a major object of the present invention to provide a control surface which is extensible from its normal position at the trailing edge of the wing, both rearwardly and outwardly away from the longitudinal plane of symmetry of the aircraft. It is a further object to provide such an extensible control surface which is particularly adapted for use with airplanes of the tail-less or flying wing type and in which the surface is controllable in both its normal retracted and extended positions. It is a still further object to provide mechanism for the concurrent extension of a pair of such control surfaces which mechanism is such that these surfaces may be supported for their operation in any position intermediate their retracted and extended positions.

It is also an object of this invention to provide an extensible surface which is capable of use as an aileron for lateral control and as an elevator for longitudinal control. It is a further object to provide actuating mechanism for the differential operation of said surface as an aileron in each of its extended positions and for its simultaneous operation as an elevator. A further object resides in the provision of such a combined aileron-elevator surface which is appreciably extended outwardly from the plane of symmetry of the aircraft to improve its effectiveness as an aileron and which is extended rearwardly from the center of gravity of the airplane to increase the effectiveness of the surface as an elevator. Other objects and advantages of this invention will become apparent to those skilled in the art after reading the present specification together with the drawings forming a part hereof in which:

Fig. 1 is a plan view of a tail-less type airplane to which the present invention has been applied;

Fig. 2 is a transverse sectional view taken through the wing, the flap and the extended balancing surface along the line II—II of Fig. 1, showing diagrammatically the nature of the forces developed by the flap and the improved balancing surface;

Fig. 3 is a transverse sectional view, similar to Fig. 2, showing the flap and balance surface in their retracted positions;

Fig. 4 is an isometric view of the operating mechanism by which the auxiliary surface is extended and rotated into its operating positions;

Fig. 5 is a similar isometric view of a form of control mechanism by which the pair of auxiliary surfaces is differentially or concurrently actuated; and

Fig. 6 is an isometric view of a modified form of the mechanism shown in Fig. 4 but in which the rotation of the auxiliary surface is cable controlled.

Referring now to Fig. 1, there is shown a plan view of an airplane of the tail-less type provided with a body or fuselage B, having a control cabin or cockpit C and a main sustaining surface or wing W. While the present invention has been shown and described as particularly adapted for use with tail-less or flying wing types of aircraft, it is pointed out that this invention is not limited to use therewith. The airplane may preferably be provided with power plants P driving tractor propellers, as well as vertical surfaces R at the wing tips for rudder or steeering control, and high lift flaps F for landing and take-off purposes. It will also be understood that the flaps F may extend fully beneath the fuselage as a continuous auxiliary lift member, or the airplane may be of the flying wing type in which there is no fuselage as such, and the pilot control position may be housed entirely within the wing.

The improved control surface of the present invention is indicated in Fig. 1 by the letter A as shown in full lines in its rearwardly and outwardly extended position. Its operating mechanism is indicated generally in dotted lines by the numeral **10**, with the mechanism for rocking the surface indicated at **11**, and the mechanism for extending the surface indicated as at **12**. Both the flap F and the balancing surface A are shown in their rearwardly extended positions in Fig. 1, as well as by the full line portions of these surfaces in the cross-sectional view in Fig. 2. In the latter figure the C. of G., or center of gravity, is indicated with respect to the wing profile W and the broken line F*a* extending downwardly and rearwardly therefrom indicates the moment arm of the positive lifting force F*f* developed by the extended flap F. Similarly, the rearwardly extending line A*a* from the C. of G. toward the balancing surface A represents the moment arm of the negative force A*f* developed by the balancing surface.

The flap F is projectable in a well known manner rearwardly and downwardly from the dotted line position in which it is nested within an undersurface recess in the wing W to the extended position shown in full lines in Fig. 2. The balancing surface A is extendable upon a bracket assembly indicated generally by the dotted line **13**; in which extended position it is rockable about the axis of its pivot A*p* into the upper dotted position A*u*, and through its neutral or normal position into its lower or downward position A*d*. It will accordingly be noted that as the flap F is extended for take-off, landing or other flight condition it velops a positive lifting force or moment abou center of gravity of the aircraft (C. of G. cause the same to dive, but that this force ca balanced by a relatively smaller downwar negative lifting force acting through a longer ment arm developed by the control of the bal ing surface A. In the neutral retracted posi of the flap F and the auxiliary balance surfa they both form the trailing portions of the W as shown in Fig. 3.

As indicated generally in Fig. 1 the mecha for rocking the auxiliary balance surface A a its pivot comprises the push-pull and to shafts **14** and **15**, respectively, which extend wardly through the fuselage B from the pilot sition at C to a conversion unit **16** from w torque shafts **11** extend laterally spanwise o wing to the actuating mechanism generally cated at **10** in the region of the vertical piv of the surface supporting bracket **13**. The ance surfaces A are preferably projected their extended positions by means of a mo controllable from the pilot position at C and ating the swinging brackets **13** through the mentioned mechanism indicated generally and to be further described in detail below in nection with Fig. 4.

Referring now to Fig. 4, a rear spar or spanwise structural element of the wing is cated at W*s* and has fixedly attached to the side thereof a pair of brackets **19** which are tically bored to provide the journal for the br et pivot **17**. It will be understood that th sembly shown in Fig. 4 represents the in portion of the surface A as indicated at the l Fig. 1. Two bracket arms **13** are provide each balance surface A and a vertical brack is provided for the support of each bracket **13**.

Rotary pilot forces transmitted through torque shaft **11** are transmitted through sheave or sprocket **20**, and the cable or cha to the sprocket **22**, which is similarly fixed t outer end of the shorter torque shaft **23**. T inner end of the latter there is fixed a bevel **24** which is continually in mesh with the bevel gear **25** fixed to the upper end of the shaft **17**. The bevel gear **25** is in mesh w like bevel gear **26** which is keyed or othe fixed to the shaft **27**, journalled as at **28** a within the bracket arm **13**. The outer e the shaft **27** has keyed thereon a further gear **30** which engages a like bevel gear **31** to the upper terminal of the outer pivot sha journalled on a vertical axis within the oute of the bracket arm **13**. The lower end o shaft **32** has fixed thereto a control arm **33** versally connected at its outer terminal t push-pull rod **34** which in turn is similarly nected to the control horn **35** of the ba surface A.

It will accordingly be noted that with the ance surface A in its extended full line po of Fig. 4, rotation of the torque shaft **11** wil part rotation in the same direction to the **23** and its gear **24** which will cause to r through the idler gear **25** and the gears at end of the shaft **27**, the gear **31** and its att vertical shaft **32** to cause rocking of the ba surface A about its substantially horizontal axis A*p*.

Referring to Fig. 5, the conversion unit **16** prises essentially a differential gear assembly sisting of a pair of opposed bevel gears **36** a rnalled for rotation upon aligned axes and ing a beveled pinion 38 interposed therebe- en and in continual meshing engagement with h of the larger gears. A housing 39 encloses three bevel gears referred to and is provided ı hubs or journal portions 40 within which shafts all are adapted to rotate. The hous- 39 is also provided with a radially aligned ring adapted to house the short shaft 41 upon end of which is fixed the bevel pinion 38. : forward or opposite end of the stub shaft 41 ttached to a universal joint 42, the forward f of which is internally splined to slidingly age the external splines 33 on the rearward ninal of the torque shaft 15. On the upper tion of the housing 39 there is formed a :ket 44 which by means of a clevis connection is pivotally attached to the rear terminal of push-pull rod 14.

ccordingly upon rotation of the torque shaft in either direction the bevel pinion 38 will se the bevel gears 36 and 37 to rotate in op- ite directions causing similar opposite rota- ı of the shaft portions 11 and 11a to thereby se the mechanism shown in Fig. 4, to provide osite or differential operation of the auxil- balance surfaces A for aileron action. If, ever, it is desired that each of the balance aces A be rocked about their respective hori- tal pivot axes in the same direction, either 'ardly or downwardly for elevator action, it nly necessary that the pilot prevent rotation he torque shaft 15 and move the push-pull ft 14 in the desired fore and aft direction. gitudinal movement of the shaft 14 causes cing of the housing 39 about the spanwise s of the shafts 11 and 11a, but inasmuch as shaft 15 is prevented from rotating, the bevel on 38 serves as a locking gear to cause the erential gears 36 and 37 to rotate together in same direction with the housing 39 and the fts 11 and 11a. It will be understood that ırther universal joint similar to that shown at would be provided in the forward portion of torque shaft 15 to permit this shaft to follow rotary movement of the housing 39, either 'ardly or downwardly, and to permit the spline to compensate for the variation in distance ween the centers of the respective universal its.

eferring again to Fig. 4, the mechanism gen- ly designated as 12 for the extension and re- :tion of the balance surface A will now be cribed. A motor 18, which may be either of electric, hydraulic or other type, is provided ı a gear housing 18a and a drive shaft 46 to ch is keyed a worm 47 in engagement with worm gear 48. The latter is journalled upon aforementioned vertical pivot shaft 17 and ixedly attached to rotate with bracket lever through its bolted connections to the lugs 49 reof. A double-arm yoke 50 is pivotally inted and freely rotatable upon the outer ver- l pivot shaft 32 for guided horizontal move- ıt about its vertical axis within the slotted tion 51 of the bracket arm 13. It will ac- dingly be seen that the pair of bracket arms pivotally interconnecting the rear spar Ws of wing with each pair of yokes 50 forms a par- logram linkage with its corners defined by the s of the vertical pivots 17 and 32. Accord- y as the motor 18 is operated by a suitable pi- control its driven worm 47 imparts rotation to worm gear 48 and outward parallel swing- of the arms 13, the yokes 50 and the at-tached balance surface A, which is at all times maintained in positions which are parallel to that which it occupies when retracted and nested against the trailing edge of the wing W, while at the same time it is displaced outwardly from the longitudinal plane of symmetry of the airplane. It should also be noted that the surface A is capable of being held and operated in any position intermediate its retracted and extended positions.

It will also be noted that the mechanism for the extension and retraction of the balance surfaces A is independent of the setting or control of the mechanism or the rocking of the surface about its pivot axes Ap journalled within the rearmost portion of the arms of the yoke 50. The control for the motor 18 is, however, preferably interconnected with the control means for the extension and retraction of the flap F in order that both the balance surfaces A and the flaps F be extended and retracted automatically and simultaneously unless such automatic interconnection is deliberately overridden or eliminated by the pilot. It should also be noted that the differential gear mechanism 16 shown in Figure 5 can be operated either for elevator or aileron action of the balance surfaces A regardles of whether the latter surfaces are in their retracted or extended positions. Conversely it will also be apparent that regardless of the position into which these surfaces have been rocked, the extension and retraction mechanism 12 is effective whether selectively controlled by the pilot or automatically actuated by his extension of the flaps F for take-off or landing.

In Figure 6 there is shown a modified form of mechanism for actuating the rocking of the balance surface A wherein cables and sheaves have been substituted for the several bevel gear sets shown in Figure 4. A generally similar bracket arm 52 is pivotally supported for rotation with respect to the bracket 53 supported from the wing structure and carries at its outer recessed portion a yoke 54 supporting the pivotal mounting for the balance surface A. The bracket 53 carries a vertical pivot shaft 55 upon which the arm 52 is adapted to rotate and the latter in turn carries a vertical pivot shaft 56 upon which the yoke 54 is adapted to similarly rotate. It will be understood that suitable mechanism, of which several types are known and available, will be provided to selectively impart movement in either the same or opposite directions to the cables 57, the sheaves 58, and through a continuous cable 59, to the sheaves 60, 61 and 62. These cables are preferably locked to their respective sheaves to insure positive rotation thereof and since the sheave 62 is fixedly attached to the upper terminal of three pivot shafts 56 the desired rotation of control lever 63 is obtained and the locking of the balance surface A is accomplished to the desired extent. The mechanism for projecting the surface A may be similar to that shown in connection with Figure 4.

The improved arrangement and mechanism which has been shown and described herein accordingly provides an advantageous and efficient means for balancing the diving moments which are created, particularly in aircraft of the tailless type, by the extension of the flaps, and the present invention accomplishes these results with mechanisms which are positive acting, of a high strength-to-weight ratio and relatively efficient in their operation and results. Other forms and modifications of the present invention both with respect to the general details of the respective parts are intended to come within the scope and spirit of this invention as more particularly defined in the appended claims.

We claim:

1. In a tail-less airplane a central fuselage, sustaining wings extending laterally from each side of said fuselage, directional control means associated with said sustaining surfaces, high lift flaps associated with the inboard trailing portions of said sustaining surfaces, balance surfaces associated with the trailing portions of said sustaining surfaces outboard of said flaps, means to simultaneously extend said high lift flaps and said balance surfaces into their operating positions rearwardly of said sustaining surfaces and control means for selectively adjusting the angle of attack of said balance surfaces in both their retracted and extended positions.

2. In an aircraft control system, means for extending and supporting a control surface comprising a main wing, a laterally extending rear structural member carried by said wing, laterally spaced pivotal supports carried by said structural member, laterally spaced parallel arms pivotally carried upon said pivotal supports, a yoke pivotally mounted upon the outer end of each said arm having pivotal supports to which said surface is horizontally pivoted, means to rotate said arms for the simultaneous rearward and laterally outward extension of said control surface and means to rotate said control surface in both its retracted and extended positions.

3. In a control surface operating assembly, a main sustaining surface, a control surface disposed adjacent the trailing edge thereof, pivotal supports carried by said main sustaining surface, a pair of arms pivotally mounted upon vertical axes upon said pivotal supports for swinging in substantially horizontal paths, a vertically disposed pivot carried at the free end of each of said arms, a yoke pivotally carried upon said verti arm end pivots for rotation in a horizontal p and having a horizontal pivotal connection at outer terminals for the pivotal support of control surface, means to rotate said arms f aligned spanwise positions adjacent said susta ing surface trailing edge, and control means cluding rotatable transmission elements co-axi mounted upon said vertical pivot axes to said control surface in its retracted and exten position.

HARRY A. SUTTOI
ROLF EVERS.

REFERENCES CITED

The following references are of record in file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,051,429	Merck	Jan. 28,
1,274,986	Carolin	Aug. 6,
1,889,295	Rosatelli	Nov. 29,
1,987,050	Burnelli	Jan. 8,
2,130,958	Kramer	Sept. 20,
2,156,994	Lachmann	May 2,
2,172,289	Munk	Sept. 2,
2,207,453	Blume	July 9,
2,210,642	Thompson	Aug. 6,
2,218,114	Kunze	Oct. 15,
2,218,822	Joyce	Oct. 22,
2,236,838	Robert	Apr. 1,
2,243,885	Schweisch	June 3,
2,246,116	Wagner et al.	June 17,
2,252,656	Youngman	Aug. 12,
2,313,768	Putt	Mar. 16,
2,397,526	Bonbright	Apr. 2,

OTHER REFERENCES

"Aircraft Engineering," February 1945, p 41–45.

PLAINTIFFS' EXHIBIT No. 30

This report constitutes a patent disclosure which Don Hall received 12/20/44. Before docketing this discl. a formal written discl., signed by Dr. Garbell was requested by Don Hall. Garbell was under the impression that this case was under consideration by Pat. Dept. D. A. H.'s request was made to Evers. I didn't know such a case existed.

This case relates to a "method of determining the airfoil sections to be used in new airplanes" and it is questionable whether this is truly an invention and whether it is of a patentable nature. This question would have to be determined first. If it is believed to be of a patentable nature, a signed disclosure should be requested from D. A. H. and the case docketed.

This method of determining the shape of airfoils (at 3 different points along the span) has been used in designing the models 107, 110, XB46 and has been proposed for the model 37.

[In margin]: Date? Addressee?

/s/ STEVE.

Admitted November 24, 1950.

PLAINTIFFS' EXHIBIT No. 31

Consolidated Vultee
Aircraft Corporation
General Offices
San Diego 12, California

March 26, 1947

Mr. Maurice A. Garbell
1714 Lake Street
San Francisco 21, California

Dear Mr. Garbell:

We have completed our investigation of the above referenced disclosure and have decided to inactivate it.

An extensive search of the prior art was made and in our opinion the existing patent art has a very definite limiting effect on the patent coverage that could hope to be secured. We do not feel that the coverage that might be obtained warrants us in prosecuting this disclosure through the United States Patent Office.

CVAC is not utilizing your invention and inquiries to our engineering force indicate that there is no contemplation that it will be used in the future. We have been informed that considerable research by our wind tunnel and aerodynamic groups would be entailed before the utility and efficiency of your construction could be determined, and until such research was performed it would not be considered for use in any of our designs.

Thus since your invention is in the paper stage and there is no use made of it and no contemplated use in mind and the extent of patent coverage doubtful, the Patent Department is inactivating this case.

Very truly yours,

CONSOLIDATED VULTEE
AIRCRAFT CORPORATION

/s/ WALTER J. JASON,
Patent Department.

WJJ/jp

Consolidated Vultee
Aircraft Corporation
General Offices
San Diego 12, California

April 7, 1947

Dr. Maurice A. Garbell
1714 Lake Street
San Francisco 21, California

Dear Dr. Garbell:

In my letter of March 26, 1947, the docket being discussed was inadvertently omitted from the heading of the letter. The reference which was omitted is as follows:

High Speed Air Intake Docket 1129-P.

Yours very truly,

CONSOLIDATED VULTEE
AIRCRAFT CORPORATION,

/s/ WALTER J. JASON,
Patent Department.

WJJ:mm

Admitted November 24, 1950.

PLAINTIFFS' EXHIBIT No. 32

S. D. Dev.

Garbell, M. A. 661-379745 SDD

234-A-22	Slotted Armor Plate	3/30/43	Inactive
301-D-19	Retractable Tail Surfaces	4/ 1/43	Inactive
1129-C	High Speed Air Intake	11/18/44	Inactive
1128-R	Hydrofoil	11/18/44	Inactive
1144-P	Droppable Jet Augmentor	12/ 1/44	Inactive
1237-D	Wing Tip Fin for Tailless Airplane	3/ 1/45	Inactive
1336-D	Longitudinal Control for Jet Aircraft	4/30/45	Inactive
1562-Q	Method of Airfoil Section	1/24/46	Inactive

Admitted November 24, 1950.

DEFENDANTS' EXHIBIT B

(Exhibit 11 (Answer to Interrogatory XXXVI))

Confidential

Consolidated Vultee Aircraft Corporation
Development Engineering, San Diego, Calif.

March 7, 1944

Summary of Wind-Tunnel Tests of a Power-Off 0.058-Scale Model of a Proposed Two-Engine Tailless Design

Preliminary tests of a proposed Two-Engine Tailless Design were made on a 0.058—scale power-off

Defendants' Exhibit B—(Continued)

model in the Galcit 10-foot wind tunnel during the period of February 28 to March 5, 1944.

These tests indicate the revised wing described in Reference 1 is satisfactory from the viewpoint of static longitudinal stability even though the stall, with elevator zero and deflected up for trim at high CL's, and from the viewpoint of elevator effectiveness with flaps up (dCm/dSe = —0.004; see Figure 1).

The characteristics of turbulent separation near and at the stall, as indicated by tuft surveys and three-component force data obtained during the present tests are greatly improved on the new wing over those of the old wing summarized in Reference 2. This is evidenced by:

1) The stall begins at the 35 per cent span point near a CL of 0.9 (elevator zero) and spreads slowly spanwise along the trailing edge (Figure 2).

2) The lift-curve slope is straight up to CL = 0.9, as compared to a separation bend near CL = 0.7 encountered with the old wing.

3) The pitching-moment curve is stable through the stall as compared to the unstable separation kink found in Reference 2. From miscellaneous wind tunnel data on various recent tailless designs it is found that similar desirable stall characteristics are not obtained on other tailless designs with flaps retracted. A comparison report on these data is being prepared.

Figure 1 shows that the relatively enlarged fuse-

Defendants' Exhibit B—(Continued)

lage and nacelles on the new model have a greater destabilizing effect on the static longitudinal stability of the complete configuration than on the old model. Steps are being taken to reduce the fuselage and nacelle overhangs ahead of the wing leading edge, and a modified model will be tested before the conclusion of the present Galcit test period (March 13, 1944).

The first runs of the present test series had indicated an adverse effect of the fuselage on the pitching-moment coefficient at zero lift (in a diving sense) and hence on the trim lift coefficient with zero elevator (toward lower trim). A reduction of the wing incidence at the fuselage from 5° to 2° eliminated this disturbing effect of the fuselage on the trim lift coefficient without any other undesirable consequences, as shown by Figure 3.

The drag of the new model does not differ substantially from that of the previously tested model, as shown in Table 1. It is interesting to note that the value of the span efficiency e is greater on the new model.

Directional stability tests made during the present test period are held in doubt as the fin airfoil section, which is critical for proper stability through zero yaw, has been found to be in error. The San Diego model shop is building a new set of fins with the proper section (NACA 4306), and the new fins will be tested on the revised power-off model and on the power-on model which is in the tunnel now.

Defendants' Exhibit B—(Continued)

References:

1) Report on Selection of Airfoils for the Revised Wing of the Two-Engine Tailless Airplane. C.V.A.C., Dev. Eng., Report ZA-101; February, 1944.

2) Report on Galcit Wind Tunnel Tests of a 0.0639—scale Model of a Two-Engine Tailless Airplane. C.V.A.C., Dev. Eng., Report ZT-021; December, 1943.

By /s/ M. ROGERS,

By /s/ W. E. STROHMEYER,

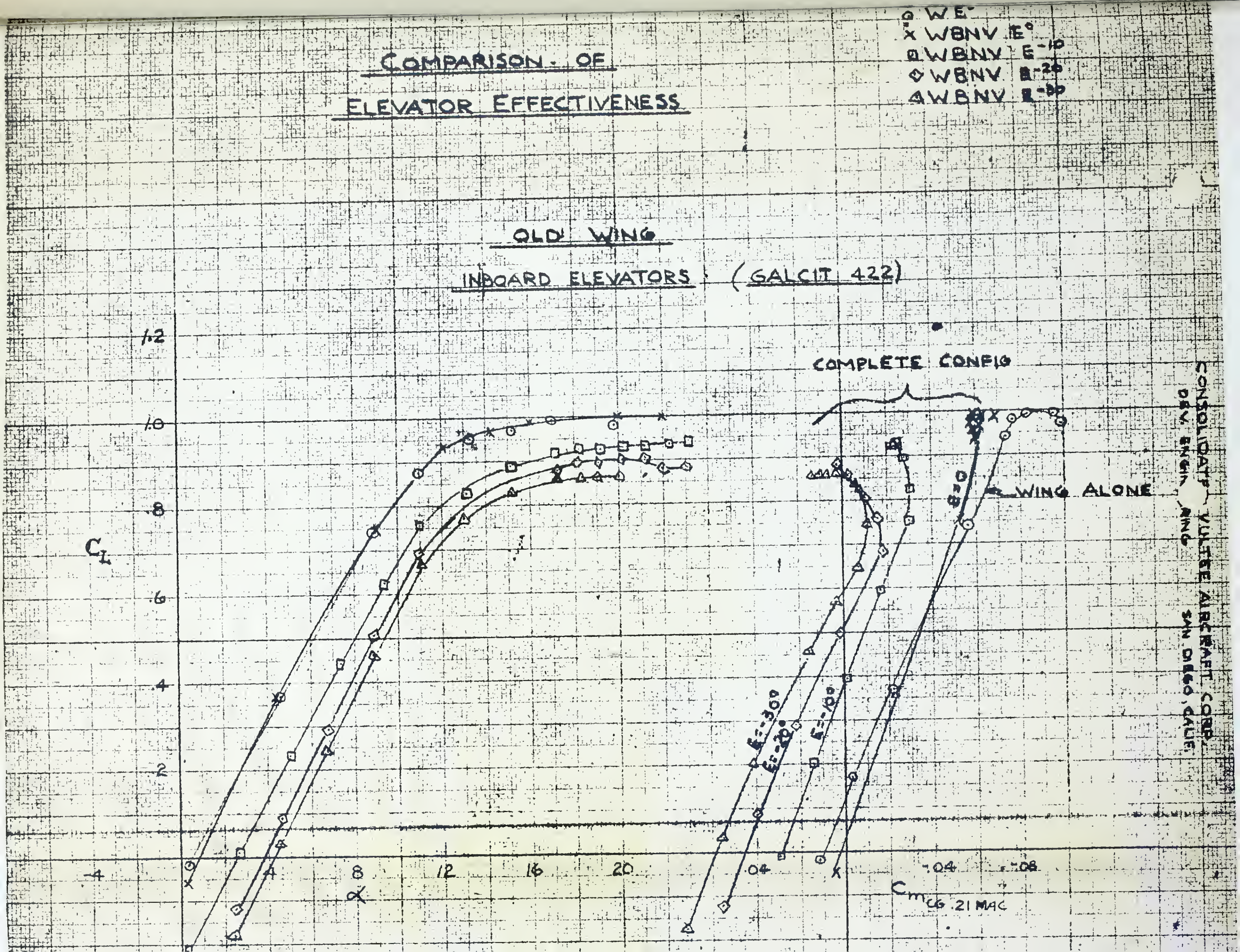
Checked:

/s/ M. A. GARBELL.

Approved:

....

Prepared at Galcit.


COMPARISON OF
ELEVATOR EFFECTIVENESS
OLD WING
INBOARD ELEVATORS (GALCIT 422)
○ W E°
x WBNV E°
□ WBNV E-10
◇ WBNV E-20
△ WBNV E-30
COMPLETE CONFIG
WING ALONE
E=-30°
E=-20°
E=-10°
E=0
1.2
1.0
.8
.6
.4
.2
-4
4
8
12
16
20
.04
-.04
-.08
CL
α
Cm CG .21 MAC
CONSOLIDATED VULTEE AIRCRAFT CORP.
DEV. ENGR. WING
SAN DIEGO, CALIF.

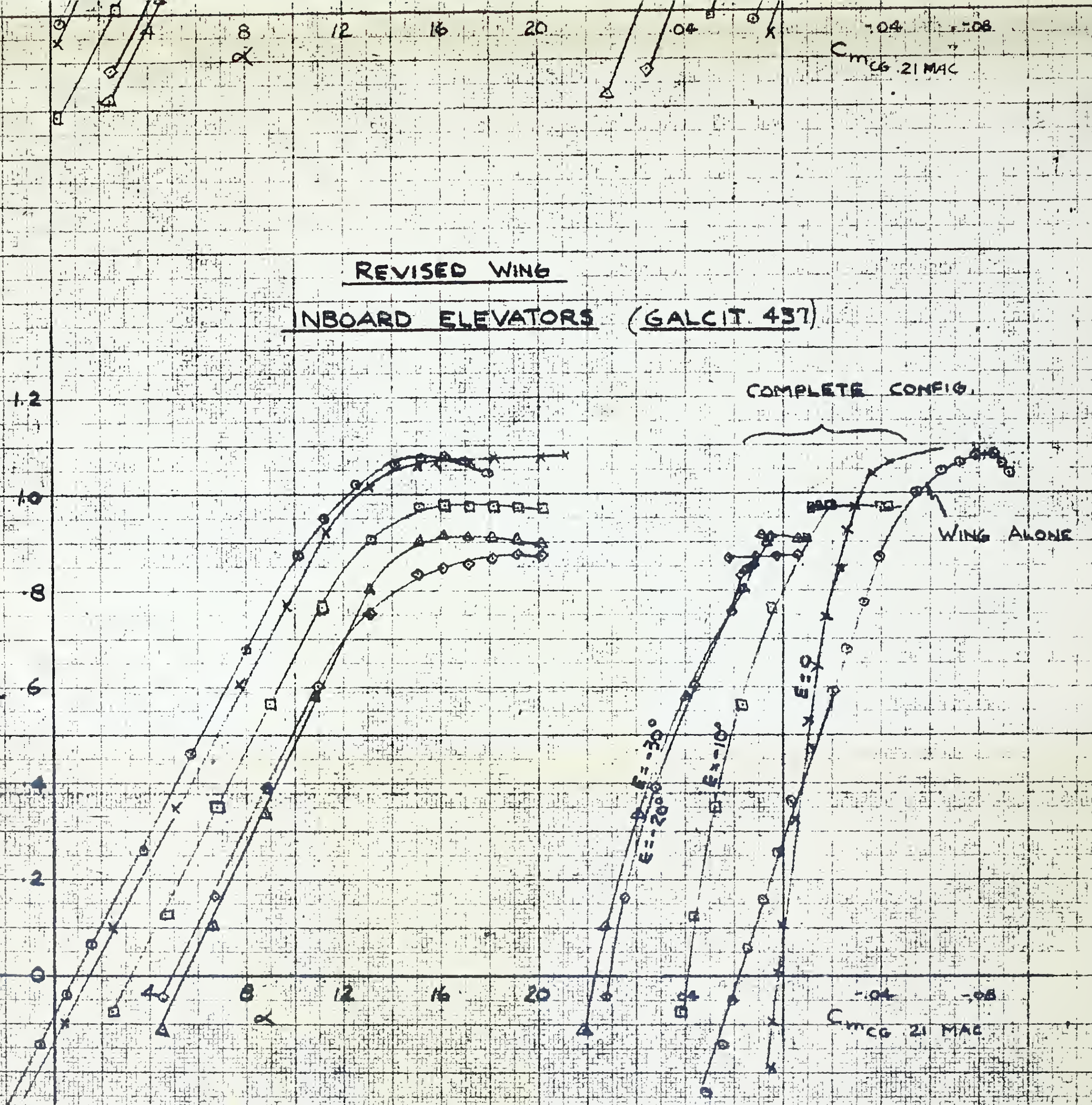


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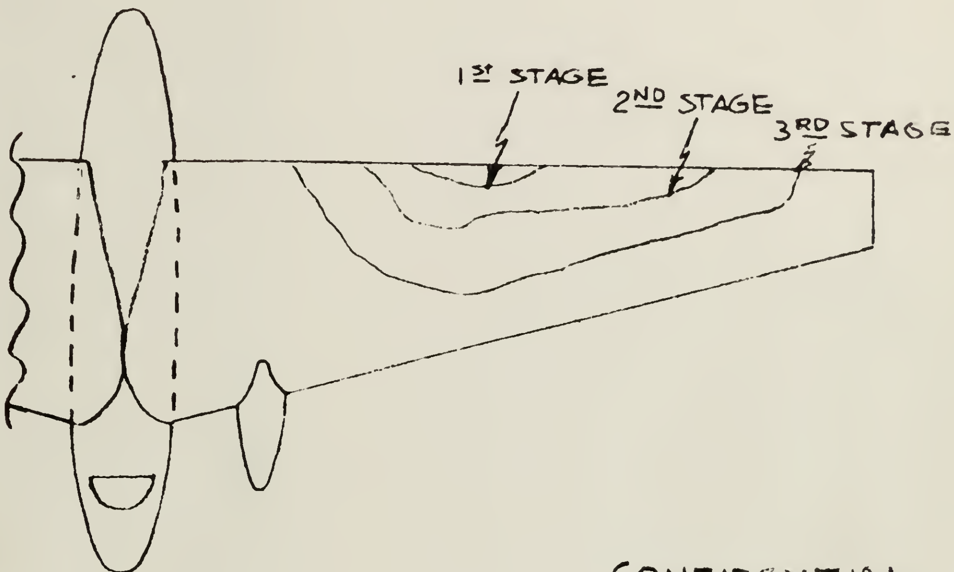
FIG. 1

PAGE OF 8

COMPARISON OF STALL CHARACTERISTICS

FIG. 2



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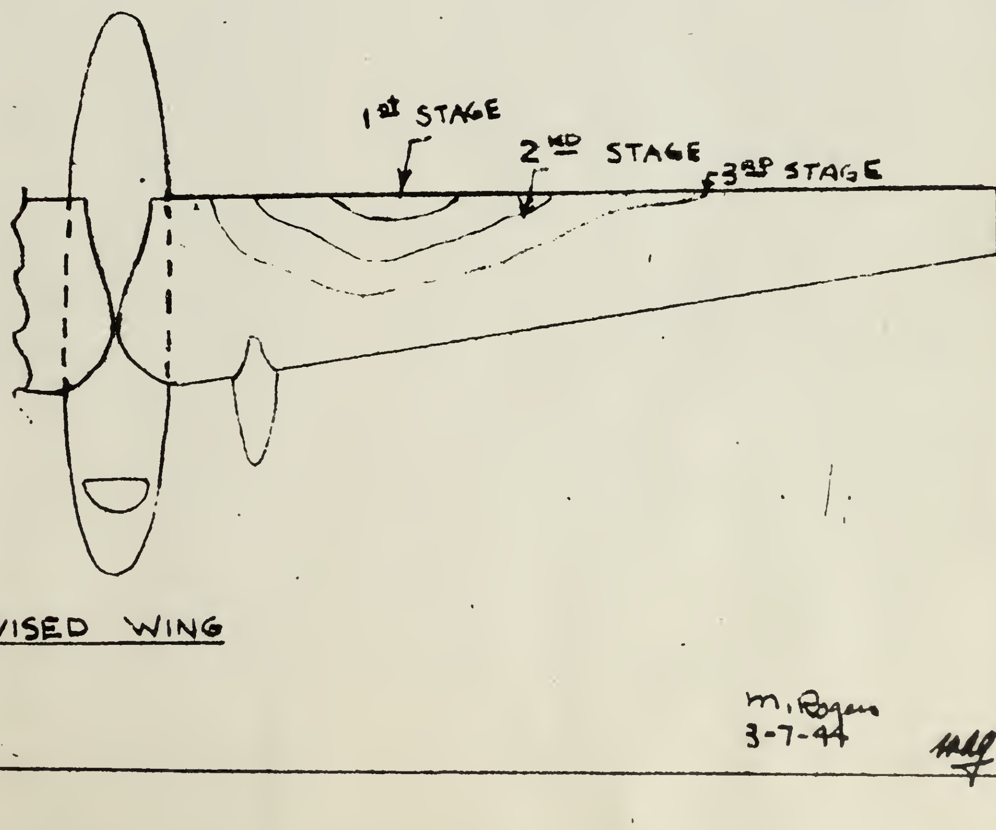
OLD WING

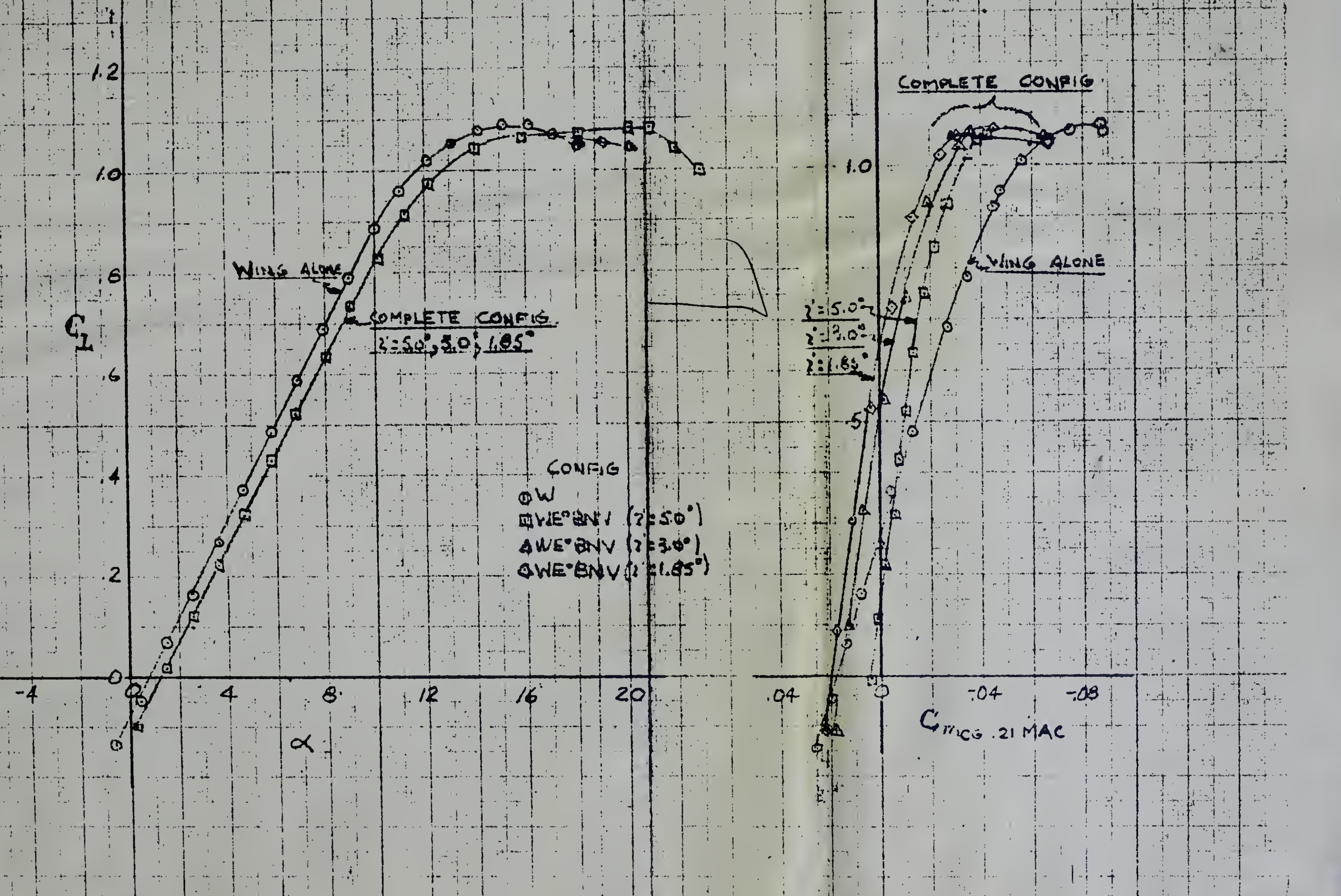


REVISED WING

M. Rogers
3-7-44

FIG 3

EFFECT OF WING INCIDENCE (GALCIT 437)



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M. Rogers
3-8-44

CONSOLIDATED VULTEE AIRCRAFT CORP
DEV. ENGINEERING SAN DIEGO, CALIF.

FIG. 4

FLAP EFFECTIVENESS (GALCIT 437)

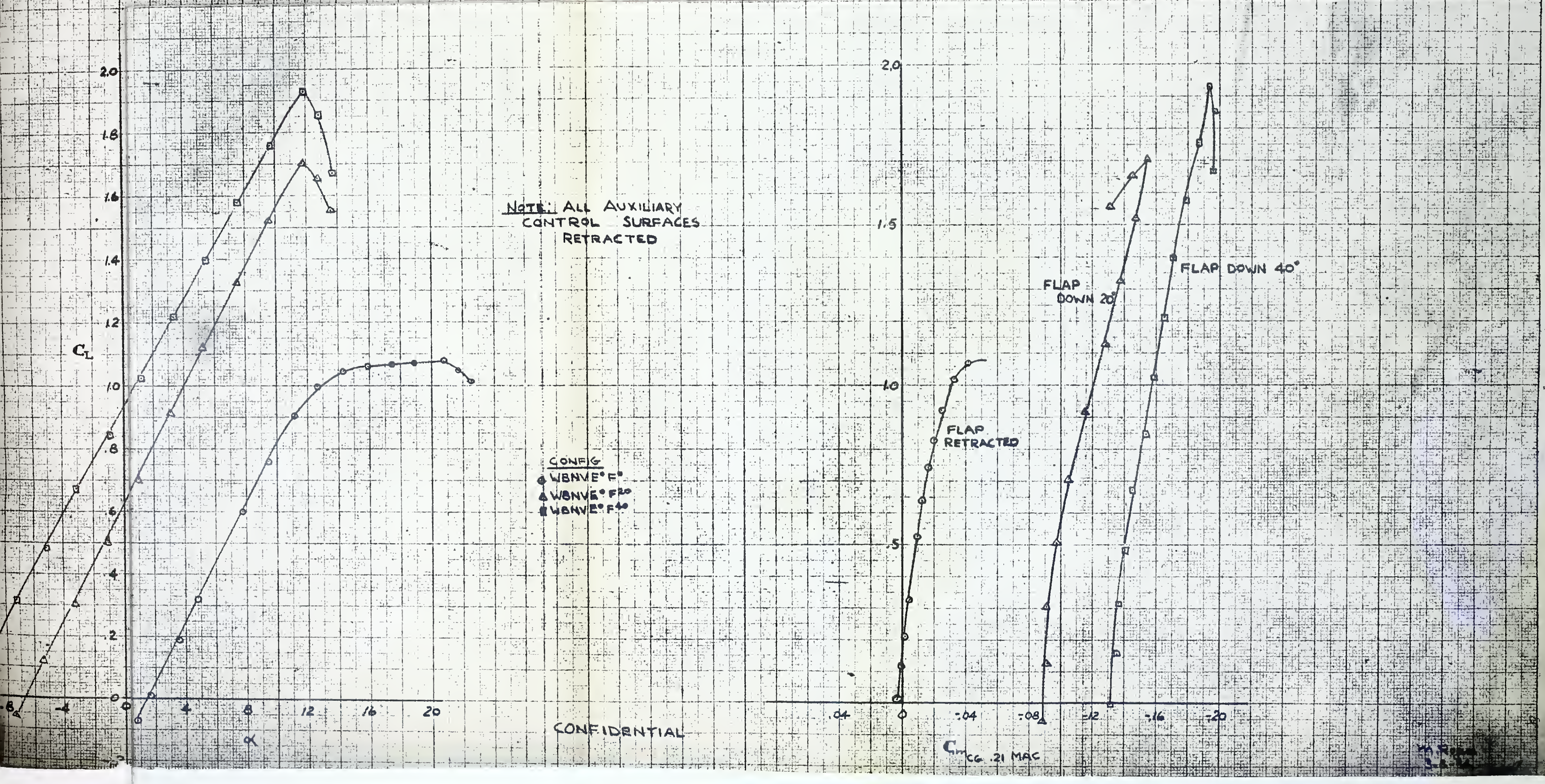

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TABLE I.

SUMMARY OF DRAG VALUES.

	Old model GALCIT 422			Present model GALCIT 437		
Configuration	C_{DP} at C_L=.3	C_{DP} at C_L=.6	e average	C_{DP} at C_L=.3	C_{DP} at C_L=.5	e average
W Wing	.0086	.0103	.835	.0087	.0092	.933
WB Wing + Body	-	-	-	.0100	.0105	.935
WBN Wing + Body + Nacelles	.0119	.0133	.855	.0122	.0134	.855
WBNV Wing + Body + Nacelles + Wing-tip fins	.0137	.0142	.945	.0139	.0147	.900

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

PD #400
March 31, 1944

Subject: B-32 Wing Incidence

Reference:
(a) Mr. T. P. Hall's memo #1922, dated March 25, 1944
(b) CVAC Report #ZT-33-001, "Wind Tunnel Test of ZB-32; Part VII; Power test with 5° and 3° wing incidence" February 10, 1941; Ref. Galcit 287-E
(c) CVAC Report T-33-008: "Report on UWAL Wind Tunnel. Test to study flow condition at tail location of the B-32 airplane." October 25, 1943.

In compliance with Reference (a), the following information on the history of the wing incidence on the subject airplane has been compiled.

The original decision regarding the wing incidence was based on the conclusions of Reference (b). The two criteria for the decision to use 3° incidence were static longitudinal stability with power on and drag. The following summarized values indicate the effect of wing incidence on these two items:

Wing Incidence	Static Long. Stability (C.G. = .25 MAC)		Parasite Drag C_{Dp}	
	Power off	Rated Power	C_L = .3 High spd.	C_L = .75 Cruise
3° (Runs 121 and 127 of Ref. (b))	-.17	-.16	.0299	.0330
5° (Runs 7 and 125 of Ref. (b))	-.18	-.14	.0302	.0333

The increase in drag was considered acceptable; however, the 3% greater destabilizing effect of power was considered prohibitive.

Wake surveys presented in Reference (c) justified the choice of the 3° incidence. In this reference it is concluded that, in order to avoid buffeting "the lowest tail position practicable is recommended". A change of wing incidence from 3° to 5° will effectively raise the tail 11 1[illegible] inches, and increase the extent of the buffeting range.

HAS requested we show conditions for which drag values are listed
i.e. TRIM POLAR ETC.

By Magarrell
Checked Bayless

78

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Aero Memo—#238
April 13, 1944.

Mr. T. P. Hall
Mr. M. A. Garbell

Wind Tunnel Tests of Two-Engine Tailless Airplane at M.I.T.

Enclosure: (A) Three (3) Plots of Preliminary Wind Tunnel Data.

The power-off tests of the two-engine tailless airplane were conducted from March 28 to April 7. The wing was modified from the wing tested in Galcit. The present wing has 14° leading edge sweepback as against the 11° and 15° sweepback previously tested during the early part of March. The fuselage was shortened and the wing incidence set at 2°.

The elevator effectiveness and stall characteristics with flaps up (Fig. 1) are impared by the faulty model (there is a slight difference in wing incidence as borne out by unsymmetrical stall patterns) and by the angularity of the wing airfoils caused by the rotation of the wing about an arbitrary point on the root chord to obtain the desired sweepback. The effectiveness of the outboard elevators (extending from the outboard end of the present inboard elevators to the wing tip) is almost twice that of the retracted high-aspect ratio aft surface elevators.

The elevator control available at the stall with

Defendants' Exhibit B—(Continued)

flaps extended is shown in Figures 2 and 3. The original high aspect-ratio aft surface (A=17) was tested in two horizontal positions along the root chord line (142 inches and 166 inches aft of the retracted position). At the shorter tail position, the lower elevator effectiveness was offset by the reduced static longitudinal stability so that elevator control, with either configuration, is powerful enough to stall the airplane. However, both horizontal positions of the high-aspect ratio tail show the same tail stall and marginal longitudinal stability at low lift coefficients with large up elevator deflections.

A lower aspect-ratio tail of 7, with approximately 20% more area, was tested 182 inches aft of its retracted position (Fig. 3). The elevator control is powerful enough to stall the airplane at CL max= 2.3 (full scale) and the tail stall experienced with the high-aspect ratio tail is eliminated.

M. A. GARBELL.

MR:EML

cc: Dev. Engr. File
Aerodynamics Ofc. #16

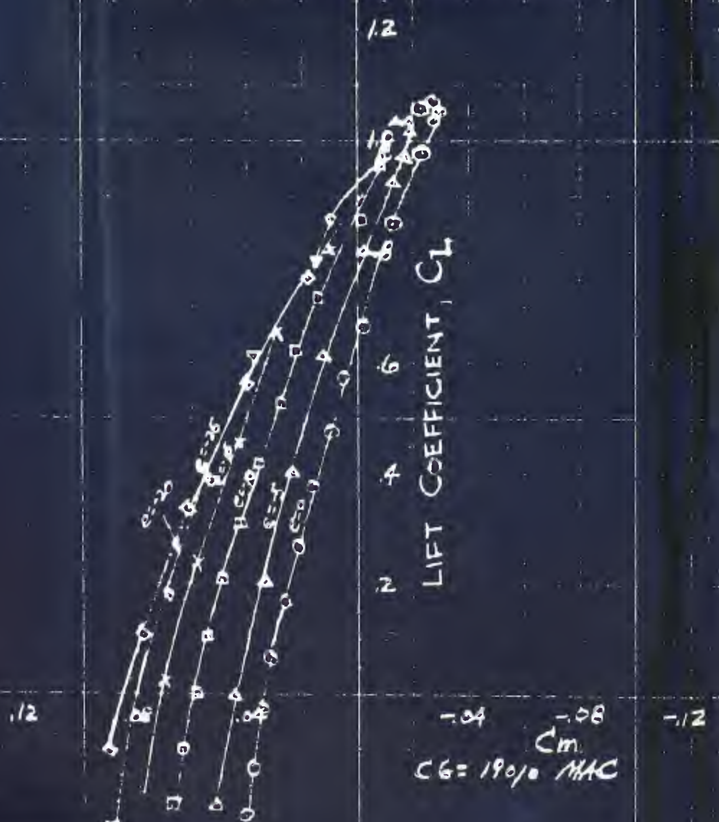
M.I.T. TESTS
2-ENGINE TAILLESS DESIGN
MAR.-APRIL 1944

PRELIMINARY DATA

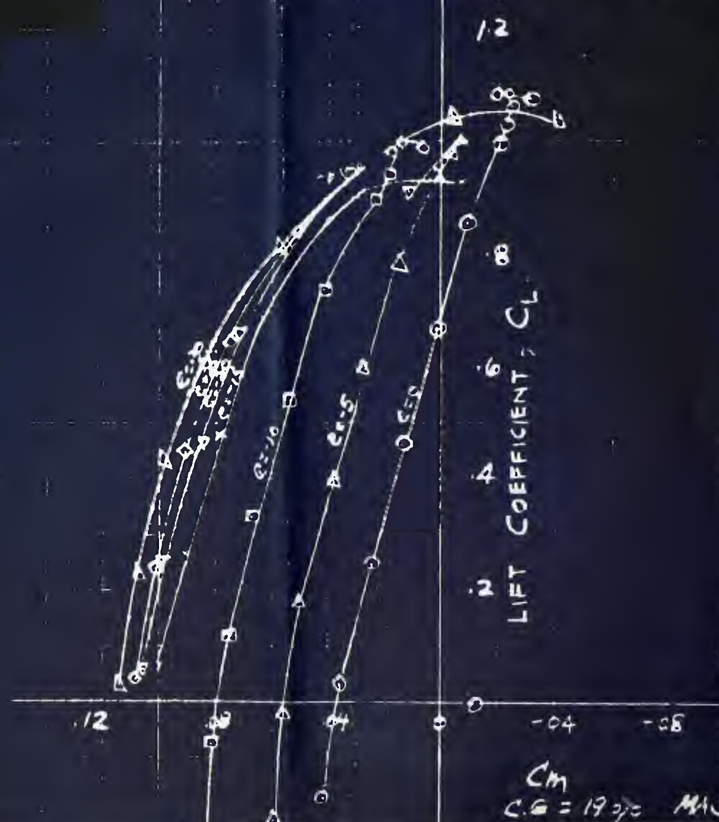
FIG. 1
ELEVATOR EFFECTIVENESS
FLAPS UP

COMPLETE MODEL

INBOARD ELEVATOR



OUTBOARD ELEVATORS

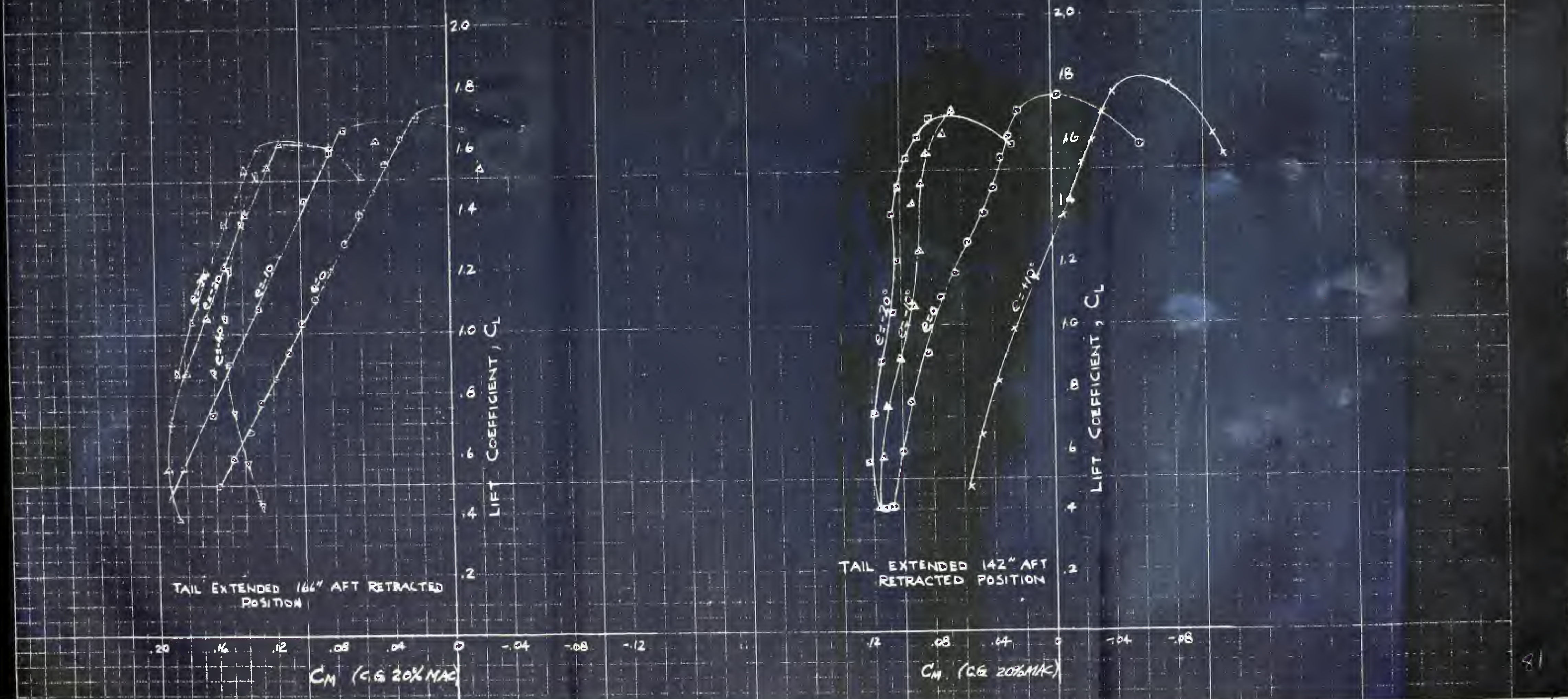


M.I.T. TESTS
2-ENGINE TAILLESS DESIGN
MAR.-APRIL 1944

PRELIMINARY DATA

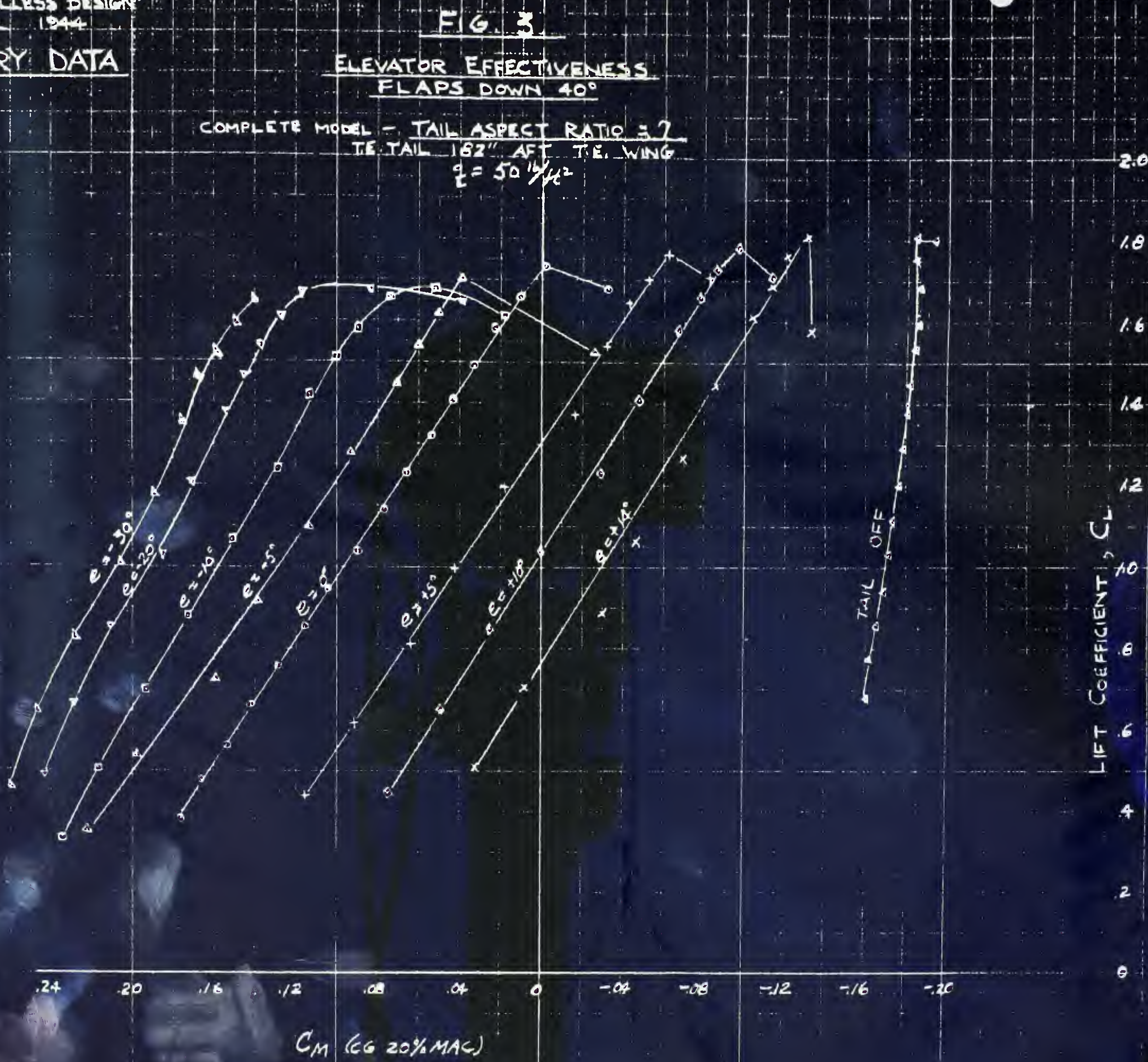
FIG. 2
ELEVATOR EFFECTIVENESS
FLAPS DOWN 40°
COMPLETE MODEL - TAIL ASPECT RATIO = 17

q = 50 lb/ft²



M.I.T. TESTS
ENGINE TAILLESS DESIGN
MAR-APRIL 1944

PRELIMINARY DATA



Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Aero Memo #250
April 15, 1944

Mr. M. Rosenbaum
Mr. M. A. Garbell

Longitudinal Stability and Control Data for Structures. XB-32 Airplane with B-29 Single Tail Installation.

(a) A.V.C. from M. Rosenbaum to C. Blake dated March 10, 1944.

(b) Aero Memo #206 dated March 23, 1944.

In accordance with your request, reference (a), and superseding the data given in reference (b), aerodynamic data for the XB-32 airplane with the B-29 single tail installation is presented in the enclosed table. All data were estimated from the last Galcit test of the airplane, as little flight test data are available.

M. A. GARBELL.

cc. Dev. Engr. File
Aerodynamics Ofc. #16

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Aero Memo #260
April 19, 1944.

Mr. C. B. Carroll
Mr. M. A. Garbell

B-32 Intercooler Exit Flap and Effect on Tail Buffeting.

Enclosure (A) One (1) copy Intercooler Air Spillway Installation on B-32 Airplane drawing.

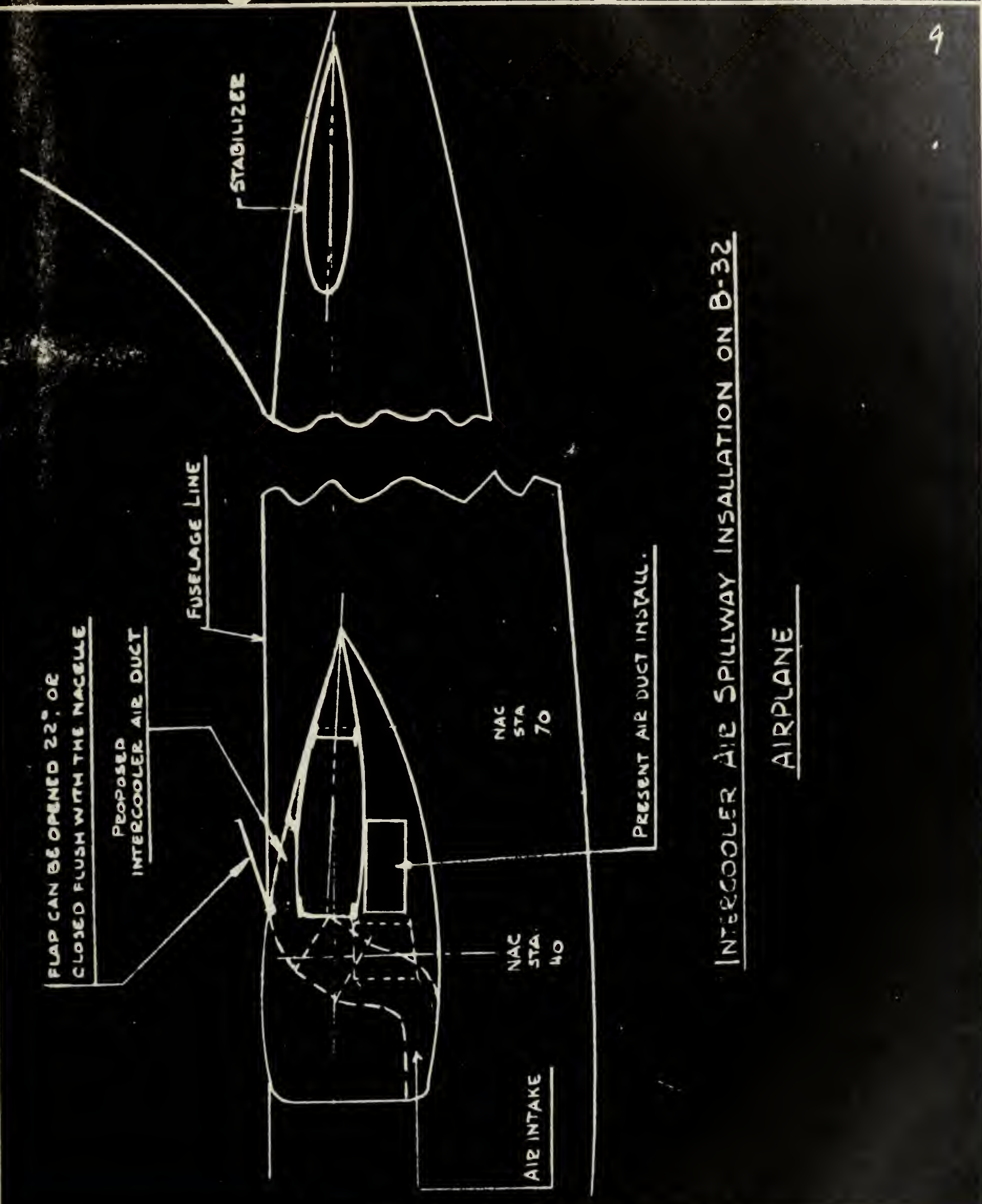
The attached figure shows the approximate relative location of the proposed intercooler flap installation on the B-32 and the present installation on the XB-32. It is expected that the introduction of the intercooler air into the upper portion of the wing wake, together with the disturbance caused by the exit flap, will intensify the tail shake to a similar degree as the upper engine cowl flaps.

It is believed that, from the standpoint of tail shake, the XB-32 intercooler exit arrangement is preferable.

M. A. GARBELL.

WSS:EML

cc: Dev. Engr. File
Aerodynamics Ofc. #16



DRAWN	SKOBLIN	4-15-44	INTERCOOLER AIR SPILLWAY INSTALLATION ON B-32 AIRPLANE	PART NUMBER
APPROVED				
APPROVED			CONSOLIDATED AIRCRAFT CORPORATION LINDBERGH FIELD · SAN DIEGO, CALIF.	

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

Aero #261
April 19, 1944

WIND-TUNNEL TEST OF THE SKYCOACH

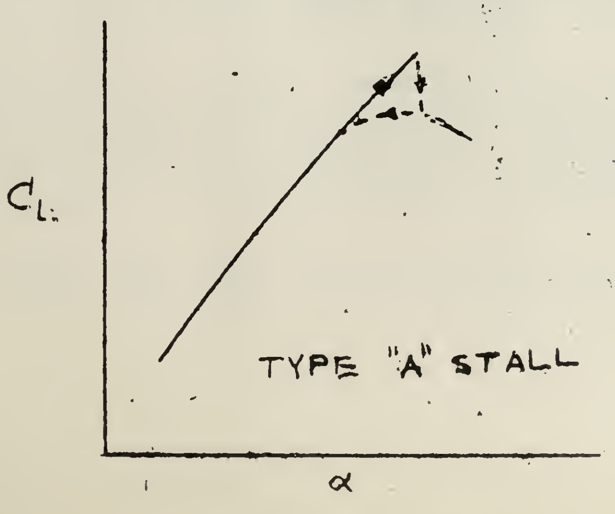
Reference: (a) Mr. A.G. Tsonga's Memo to Mr. T.P. Hall, dated April 8, 1944
(b) Engineering Report No. 1486, CVAC Stinson Division dated Dec. 31, 1943

The suggestion to change the geometric washout of the Skycoach model wing from 0° to 3° (contained in Reference (a)) has been studied, and the following comments are made:

1. The original washout distribution as shown on page 5 of Ref. 2 had zero washout from the wing root to the tail boom juncture and 1.9° washout at the wing tip. Our earlier studies of the Skycoach showed that this wing design would have satisfactory stalling characteristics. The wing stall with this washout distribution and the latest planform should start at the booms. The outboard 30 percent wing-span portion of the wing containing the ailerons should remain unstalled until the flow over the entire inboard portion of the wing is stalled.

2. The change to 0° washout in the present design is not understood. We were informed of this change only when the model drawings arrived here for the construction of the model. The stalling characteristics of this wing are anticipated to be somewhat unfavorable. The stall will probably start simultaneously at the tail boom-wing juncture and the inboard end of the ailerons and will spread evenly toward the wing root and tip. It is believed that the washout distribution of the original design should be used.

3. A further study of the airfoils to be employed shows the questionable value of the five-digit airfoils proposed for the Skycoach. Both the root airfoil (23015) and the tip airfoil (43012-A) have stall characteristics of the type "A" shown below, that is, have different stalling and unstalling lift curve peaks, as shown.

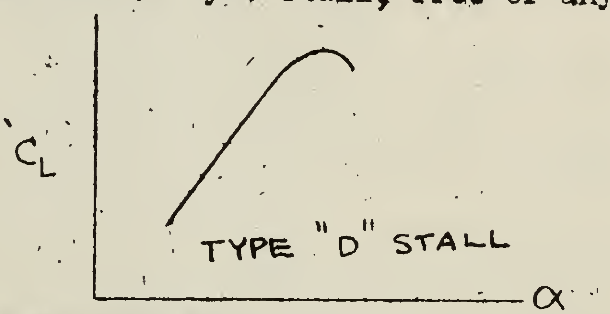


CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . SAN DIEGO, CALIFORNIA

Aero #261
4-19-44

If the airplane is brought to a stall, a temporary premature separation will make one wing follow the lower stalled lift curve (see above sketch) while the other wing follows the upper unstalled lift curve. A decided dive is then necessary to put an end to the ensuing rolling moment, as corrective aileron action contributes only to aggravate the unsymmetric stall and the auto-rotative tendency of the airplane.

The use of the NACA 2415 section at the wing root and the 4412 section at the tip would improve the stalling characteristics and the handling characteristics at the stall substantially, because both airfoils have a smooth "D" type stall, free of any unstalling hysteresis, as shown below:



The geometric washout with these four-digit airfoils, because of the greater difference in zero lift angles, should be 3° at the tip with zero washout at the wing boom juncture.

The increase of drag of about ΔC_{D_p} = .0015 as obtained from NACA T.R.'s 460 and 661, caused by a change from the present five-digit airfoils to the more desirable four-digit airfoils is purely fictitious inasmuch as the greater sensitivity of the five-digit airfoils to surface roughness equalizes the drag of two wings of comparable normal manufacturing quality. The theoretical loss in section C_{Lmax} of about .15 is also not believed to be representative of the actual $C_{L\,max}$ of the airplane because the tail booms have a greater detrimental effect on the wing stall on the five-digit airfoils (as evidenced by the tuft photos in Reference (b)) than would be the case on a four-digit airfoil wing.

The writer made a direct comparison of a five-digit wing and a (2415-4409) wing on the same type high-performance sailplane in 1937. The results as observed and measured in flight confirmed fully the above considerations. Another example of somewhat undesirable handling characteristics at the stall due to lift hysteresis is the DC-3.

4. A second wing block for a revised wing is ready in the Model Shop. It is suggested that a revised wing be built and tested.

MWGarhtt

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Aero Memo #278
May 3, 1944

Mr. T. P. Hall
Mr. M. A. Garbell

Camber in Horizontal Stabilizer—B-32 Airplane.

(a) Memo # 1955 to R. L. Bayless from T. P. Hall dated April 3, 1944.

(b) Aero Memo # 188 to T. P. Hall from C. L. Blake dated February 25, 1944.

(c) Memo to R. C. Sebold from R. H. Widmer dated March 23, 1944.

Enclosure: (A) Doc. Aero 33-107. Revised May 1, 1944. Plot of elevator deflection for trim versus center of gravity position.

The change in camber of the horizontal stabilizer from a negative cambered section which is now on the airplane to a symmetrical section will decrease the down elevator required to trim by approximately 0.8°. This value is in agreement with Widmer's data quoted in Reference (c) when considered in terms of the effective change in stabilizer incidence.

The second paragraph of Reference (c) states that the Boeing horizontal surface was cambered to prevent the lower surface from stalling with flaps fully deflected at low lift coefficients. Our wind-tunnel data on the XB-32 with the cambered Boeing surface and with our earlier symmetrical surface show no stall even down to negative lift

Defendants' Exhibit B—(Continued)

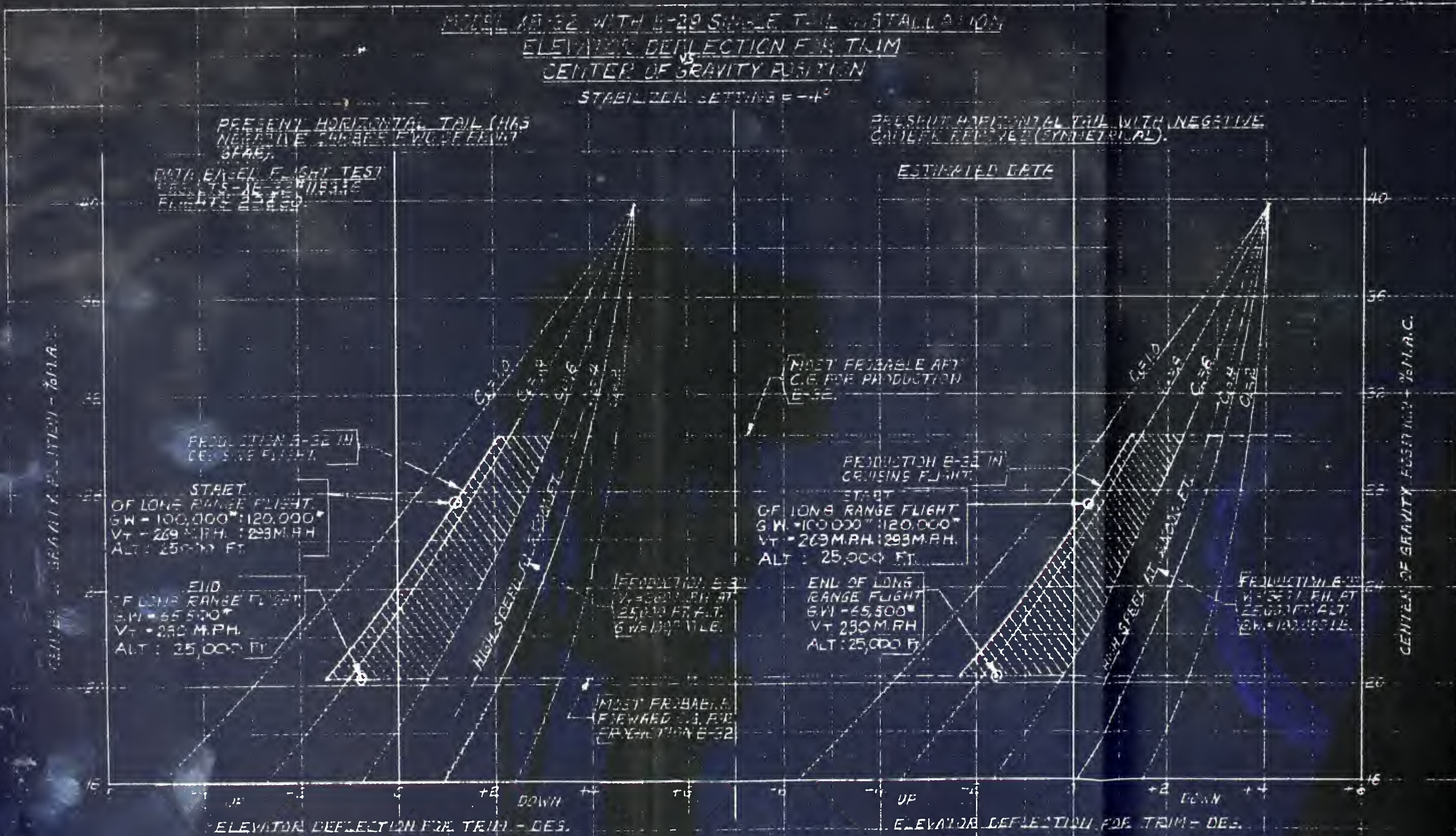
coefficients. Therefore, reforming the stabilizer nose to give a symmetrical section is considered to be permissible on our airplanes.

Enclosure (A) is similar to the chart included with reference (b) except that the CL for start of long range flight was changed from 0.9 to 0.85 to agree with recent information received from Fort Worth. Also the velocities corresponding to different gross weights and lift coefficients have been added to the original chart.

/s/ J. E. A., for
M. A. GARBELL.

VHG:dh

cc: C. B. Carroll
J. B. Jewell
Aerodynamics (2)
Dev. Engr. File



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APPROVED BY			
APPROVED BY			

REV.

CONSOLIDATED AIRCRAFT CORPORATION
LINDBERGH FIELD, SAN DIEGO, CALIF.

PAGE

DOC. NO.

MODEL XB-32

INTRA-COMPANY CORRESPONDENCE

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

Aero Memo #320
DATE May 22, 1944.

TO Mr. M. A. Garbell

FROM Mr. R. L. Bayless

SUBJECT Two-Engine Tailless Wing Fairing

REFERENCE

Mr. Sutton suggested we fair wing cut-out on tailless as follows:

Please work with Preliminary Design on this and include in next wind tunnel model if feasible.

R. L. Bayless.

RLB:EML

STINSON SKYCOACH

PRELIMINARY REPORT (IV) ON TESTS

M.I.T.

1/5 SCALE WIND TUNNEL MODEL

JUNE 8, 1944.

The fairly satisfactory wing-fuselage plasticene fillet, which as developed during the past two days, has been replaced by a more urable wood fillet. Most of the abbreviated schedule has now been ompleted.

The maximum lift coefficients

$C_{L_{max}} = 1.25$ Flaps up

$C_{L_{max}} = 1.79$ Flaps deflected 30°

$C_{L_{max}} = 1.84$ Flaps deflected 50°

ndicate normal flap effectiveness except for 50° deflection. Addi-ional future research and testing will be required to obtain a etter flap effectiveness at large angles.

The aileron effectiveness, flaps up, is adequate to give a elix angle $pb/2v = 0.085$. There is no loss in aileron effectiveness to the total wing stall.

The static directional stability after the installation of -54 type dorsal fins is satisfactory through the entire range of wing angles. The numerical value of the directional stability erivative is $dC_n/d\psi = -.0020$. There is no rudder stall up to e maximum rudder deflection of 20°.

Other data are still being computed.

The Stinson test should be completed today with the remaining wer runs for the three flap configurations.

In compliance with Mr. Sutton's request a few runs will also made to obtain constant trim C_L with the various flap deflections.

The subsequent brief tests of the Tailless Model are intended investigate a 6° wing incidence, rolling control effectiveness th the new aileron-spoiler combination (designed to give rolling ntrol without any pitching moment disturbance), and additional oblems of the extended aft surface. Our tests are scheduled to d on Saturday, June 10, 1944.

MMA

BY

CHECKED

APPROVED

STINSON SKYCOACH

PRELIMINARY REPORT (III) ON TESTS

M.I.T.

1/5 SCALE WIND TUNNEL MODEL

JUNE 7, 1944.

A continued enlargement of the aft wing-fuselage fillet did not improve the critical wing root stall any further. Careful observation of the tuft pattern near the wing leading edge, subsequently, lead to the conclusion that the basic reason for the premature flow separation consisted in the critical sensitivity of the airfoil leading edge to the unfavorable pressure distribution caused by the fuselage intersection. A fairly large leading-edge fillet, combined with the original small aft fillet delayed the undesirable wing-root separation to the angle of attack for the maximum lift coefficient ($C_{L\,max.} = 1.25$).

The installation of small dorsal fins on the vertical surfaces straightened the yawing moment curve up to the highest angles of yaw tested (21°).

The attached abbreviated test schedule is being run at present to obtain complete information on the cleaned-up configuration with flaps retracted, partly and fully extended, power-off and with rated power.

At the completion of this schedule, probably Thursday afternoon, the Tailless Model will enter the tunnel for about four days' testing.

[signature]

By

Checked

Attachment to:

STINSON SKYCOACH

PRELIMINARY REPORT (III) ON TESTS

M.I.T.

1/5 SCALE WIND TUNNEL MODEL

JUNE 7-8, 1944

1. Flaps up - Power-off and Rated power.

   (a) MDP_6 (power runs are P_6) $e = +10°, 0°, -10°, -20°$ (stabilizer set to trim at $C_L = .3$ with e = (

   (b) Y_6 $e = 0°$ $r = 0°, 10°, 20°$

   (c) P_6 $a = \pm 20°$

2. Flaps 25°-25° - power off and rated power

   (a) P_6 $e = 0°, -10°, -20°$

   (b) Y_6 $e = 0°,$ $r = 0°, 10°, 20°$

3. Flaps 50° -50° - power off and rated power

   (a) P_6 $e = 0°, -10°, -20°$

   (b) Y_6 $e = 0°,$ $r = 0°, 10°, 20°$

   (c) P_6 $a = \pm 20°$

Note: Runs (a) yield information on static longitudinal stability and elevator effectiveness.

Runs (b) indicate static directional and rolling stability and rudder effectiveness.

Runs (c) together with one run of series (a) give aileron effectiveness.

STINSON SKYCOACH

PRELIMINARY REPORT (II) ON TESTS AT

M.I.T.
1/5 SCALE WIND TUNNEL MODEL

JUNE 6, 1944

Most of the running time, during the past two days, was edicated to the improvement of the objectionable wing root stall. Although the enlarged fillets raised the break of the lift curve, power-off, from $C_L = .85$ to $C_L = 1.10$, the final reakdown of the airflow over the wing root could not be avoided. nall changes in the fillet and the installation of a small orsal fin on the fuselage top would shift the root stall from ne wing to the other, but in any case the sudden local stall ould cover a comparatively large area.

Attempts were also made to improve the flap effectiveness hich showed an increase in $C_{L_{max}}$ from 1.40 (flaps up) to only .67 (flaps 29°) and a lift decrease with further flap deflec- ion. Changes of the flap gap did not show any appreciable ain in $C_{L_{max}}$.

Dorsal fins similar to those employed on the XP-54 are eing tested today in an effort to improve directional stability large angles of yaw.

W.A.J.

ne 6, 1944.

BY

CHECKED

APPROVED

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

July 1, 1944

Mr. T. P. Hall
Mr. M. A. Garbell

Free-Flight Tests of Two-Engine Tailless Design

The following is a summary of a telephone conversation between Mr. Shortal, of the N.A.C.A., and Mr. Rogers, of the Aerodynamics Group of C.V.A.C., held June 30, 1944.

1. Free-Flight Tunnel film of the Aspect Ratio 12, Tailless Flaps-Up model, in flight, is now being reviewed at The Bureau of Aeronautics. A copy should arrive in San Diego sometime during the latter part of next week.

2. Preliminary data on the dynamic damping derivatives obtained experimentally on the original, Aspect Ratio 10 Tailless design, have already been forwarded to this company. These data were discussed with Mr. Rogers on his recent visit to Langley Field and show good correlation with the theoretical values given in C.V.A.C. Report ZA-095 on the dynamic stability of the Two-Engine Tailless Design.

3. The flaps-down model of the Aspect Ratio 12 design arrived at the N.A.C.A. in good condition. Force tests on the six component balance have already been made. At present, tuft surveys of the model are being made. The model should be flown sometime during the middle part of next week (about July 5, 1944).

4. Mr. Shortal suggested that, in view of our

Defendants' Exhibit B—(Continued)

interest in aileron-spoiler combinations and the general interest of the aeronautical industry in such data, it may be possible for the Free-Flight Tunnel to run a series of research tests to determine the time response of an airplane with this lateral control system, as well as general flight characteristics. To help him get authorization for such a general research program, Mr. Shortal suggested that this company write a letter to Dr. Lewis of the N.A.C.A. recommending that such a program be undertaken by the N.A.C.A. It is felt that owing to the basic nature of such data it may be possible for the N.A.C.A. to initiate such a program should some manufacturer request information or data of such general interest to the industry.

5. Mr. Shortal again will try to send us some Free-Flight film on the flights of another tailless design, either a basic N.A.C.A. research model or the Kaiser-Koppen Design. Permission to send us this film previously was not granted by the N.A.C.A. on the grounds that they, in all fairness to the rest of the industry, would also have to send the film to all other manufacturers. However, Mr. Shortal feels that a short term loan of the film might be arranged.

M. A. GARBELL.

MR:ms

cc: Aero. File (3), Dev. Engr. File

[In margin]: Filed, Hall.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

Aero Doc. #Misc.-120

July 5, 1944

Subject: Recommended Design Modifications to Single Engine Pusher Design.

Reference: (a) CVAC Report #ZA-030 - Wind Tunnel Test of a 1/5 Scale Powered Model, Single Engine Pusher Design.

Enclosure: (A) Sketch of present and proposed Flap Slot and Path
(B) Three view of Single Engine Pusher Design with recommended modifications.
(C) Sketch of engine air intake

The following modifications to the single engine pusher design are recommended on the basis of the M.I.T. wind tunnel test summarized in reference (a):

1. The flap slot and flap path should be modified, as indicated by enclosure (A), in order to obtain a maximum lift increment of at least ΔC_{Lmax} = 0.30 between the 25° and the 50° flap deflection. Only ΔC_{Lmax} = 0.10 was obtained in the test. The slot and path used on the model of reference (a) are those designed by the N.A.C.A. for use on the 23012 airfoil, and they are not suitable for the 23018 airfoil used on the design. The flap slot and optimum path shown by enclosure (A) are derived from the configuration 2(b) of N.A.C.A. T.R. 677, which was originally designed for the 23021 airfoil and which is believed to be equally effective for the 23018 airfoil.

2. The tail length should be increased approximately 27 inches (15% increase in tail length) and the horizontal tail chord increased 7 inches (15% increase in tail area) to give adequate longitudinal stability at the probable most aft C.G. of approximately 32% M.A.C.* The vertical tail area may be decreased 15% with this increase in tail length as the present directional stability and control are considered satisfactory.

---

*Note:
The probable most aft C.G. of 32% is based on Drawing S-43-045 which shows a design rearward C.G. of 28.2% M.A.C. It is estimated that the C.G. will move aft to approximately 30% M.A.C. with a light load and a light pilot (90-100 lb.) for the present design. This figure cannot be accurately determined due to lack of data, but appears reasonable based on earlier studies summarized in Report ZA-099. The increase in tail length and tail modification will result in a C.G. shift aft of approximately 2% M.A.C. due to the increase in weight moment. The resulting most aft C.G. is therefore 32% M.A.C.

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GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

Aero Doc. #Misc.-120

July 5, 1944

The criteria for satisfactory longitudinal stability are
based on the following data:

$\frac{dC_{M_H}}{dC_L}$ as tested = - .245 (C.G. 25%)

$\frac{dC_{M_H}}{dC_L}$ (increased tail length and area)

$= -.245 \times 1.15 \times 1.15 =$ - .325

$\Delta \frac{dC_m}{dC_L}$ (C.G. 25%)

(a) C.G. to 32% MAC	+ .07
(b) Power on	+ .02 (test)
(c) Free elevator	+ .04 (estimated)
(d) Airplane tail off	+ .145
Total	+ .275

$\frac{dC_m}{dC_L}$ (C.G. 32%), power on =

$= -.325 + .275 =$ - .05

This margin of static stability is considered adequate for
atisfactory flight characteristics.

---

3. Dorsal fins, similar to those used in the wind tunnel
ests to eliminate vertical surface stall at angles of yaw greater than
5 , should be incorporated in the design (see encl. (B)).

4. The leading edge fillet, used in the wind tunnel tests
o obtain reasonably good aerodynamic characteristics, is not a very
atisfactory solution to the wing fuselage interference and premature
oot stall problem as described in reference (a). It is possible that
he engine cooling air intake could be moved from its present position
t the top of the fuselage to two side ducts in the vicinity of the
low separation at the wing-fuselage intersection (approximately 30%
ing chord). This should relieve the unsatisfactory root stall by

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

Aero Doc. #Misc.-120

July 5, 1944

removal of the boundary layer. If the exit air was expelled at the end of the fuselage fairing below the drive shaft to relieve the bluntness of the desired fuselage fairing it appears that the ducting arrangement would be unsatisfactory, and a special fan, now provided on the propeller shaft, would be required at this exit. (See Encl. (C). If the air was expelled around the propeller spinner, as now planned, the fan would absorb greater power than at present, as the duct entrance would be at a lower pressure than the duct exit. Insufficient airplane design details are available at San Diego to investigate this modified duct arrangement. Also, air expelled below the drive shaft would probably cause objectionable interference with the propeller.

This root stall condition could probably be relieved also by use of less critical wing airfoils similar to the NACA four digit series airfoils (i.e. 2518 root and 4412 tip as compared to the present 23018 root and 43012-A tip). Although no pressure distribution data are available for the four digit series airfoils, these airfoils basically have lower peak pressures due to the further aft position of the maximum camber point. Therefore, they should be less sensitive to wing-fuselage interference. However, a trailing-edge fillet will still be necessary to relieve the fast expansion along the rear portion of the fuselage which causes flow separation and drag. The particular four-digit airfoils specified were selected to give maximum lift and low drag for the thicknesses used on this design.

By *M. A. Garl...*

Checked *[signature]*

Aero Doc. Misc. #113
July 15, 1944

CENTER-OF-GRAVITY LIMITS

Aerodynamic C.G. limits have been estimated from wind-tunnel and flight-test data.

Definitions

Aft C.G. Limit

The aft C.G. limit is defined as that C.G. position (in per cent M.A.C.) at which the static longitudinal stability derivative, dCm/dC_L, equals -0.04 with flaps up and stick free. Limits are shown for two flight conditions:

a. Cruise power (approximately 50% normal rated power), level flight, C_L = 0.7 approx.

b. Normal rated power, climb, C_L = 1.0 approx.

The numerical value, dCm/dC_L = -0.04, has been found to indicate fairly reliably the minimum static longitudinal stability margin for satisfactory flight. The Stability and Control Research Section of the N.A.C.A. (Langley Field) has confirmed this value by correlation with free-flight wind-tunnel and full-scale flight tests.

Forward C.G. Limit

The forward C.G. limit is defined as that C.G. position (in per cent M.A.C.) at which full up-elevator deflection will trim the airplane at the maximum lift coefficient at landing, power off.

Hydrodynamic and ground handling C.G. limits are also shown.

BY [signature]

CHECKED [signature]

APPROVED

C.G. LIMITS

% M.A.C.

plane	Hydro-dynamic or Ground Handling C.G. Limit	Aerodynamic Aft. C.G. limit Stick Free		Aerodynamic Forward C.G. Limit at Landing Power Off	Recommended C.G. Limits	
		Cruise Power Level Flight	Normal Rated Power Climb		Fwd.	Aft.
4J	34	30	28	23	23	28
24K	34	33	31	20	20	31
Y-2	34	33	31	20	20	31
el 39	33	33	31	20	20	31
32 ginal) Hori- al .)	40	33	31	20	20	31
9	38	42	42	26	26	38
5 t)	31 Hyd.	29	28	21 Aero. (24 Hydro.)	24	28
5A .)	34 Gnd.H. 31 Hyd.	29	28	21 Aero. (24 Hydro.)	24	28
-3 t)	34 Hyd.	32	30	23 Aero. (24 Hydro.)	24	30

: The basis for the above Aerodynamic aft. C.G. limits is shown on the following page.

BY

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Airplane	$\frac{dC_m}{dC_L}$ Power Off Stick Fixed C.G. 25% M.A.C.	Ref.	$\Delta\frac{dC_m}{dC_L}$ Cruise Power Level Flight	$\Delta\frac{dC_m}{dC_L}$ Normal Rated Power Climb	Ref.	$\Delta\frac{dC_m}{dC_L}$ Stick Free vs. Stick Fixed (Est.)	$\frac{dC_m}{dC_L}$ Stick Free C.G. 25% M.A.C. Cruise Power Level Flight	$\frac{dC_m}{dC_L}$ Stick Free C.G. 25% M.A.C. Normal Rated Power Climb	Aft C.G. Limit for dCm/dCL = -.04 Stick free Cruise Power Level Flight	Aft C.G. Limit for dCm/dCL = -.04 Stick free Normal Rated Power Climb
B-24J	-.16	ZT-32-012 (Galcit)	+.04	+.06	ZA-32-086 (Flight Test)	+.03	-.09	-.07	30	28
XB-24K	-.22	ZT-32-012 (Galcit)	+.06	+.03	ZA-32-086 (Flt. Test)	+.04	-.12	-.10	33	31
PB4Y-2	-.21	ZT-100-004 (Galcit)	+.06	+.08	Galcit 445	+.03	-.12	-.10	33	31
Model 39	-.23	ZT-39-002 (Galcit)	+.08	+.10	Est. From Galcit 445	+.03	-.12	-.10	33	31
XB-32 (Orig. B-29 horiz. Tail)	-.17	ZT-33-007 (Galcit)	+.02	+.04	Est. From Galcit 287H	+.03	-.12	-.10	33	31
XC-99	-.27	Galcit 444	.00	.00	Est. From Part II NACA Power Tests, 1/14 Scale XB-36	+.06	-.21	-.21	42	42

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MODEL AIRPLANE REPORT NO Aero Doc. Misc. #113

Airplane	$\frac{dC_m}{dC_L}$ Power Off Stick Fixed C.G. 25% M.A.C.	Ref.	$\Delta\frac{dC_m}{dC_L}$ Cruise Power Level Flight	$\Delta\frac{dC_m}{dC_L}$ Normal Rated Power Climb	Ref.	$\Delta\frac{dC_m}{dC_L}$ Stick Free vs. Stick Fixed (Est.)	$\frac{dC_m}{dC_L}$ Stick Free C.G. 25% MAC		Aft C.G. Limit for dC_m/dC_L=-.04 Stick Free	
							Cruise Power Level Flight	Normal Rated Power Climb	Cruise Power Level Flight	Normal Rated Power Climb
PBY-5	-.12	Galcit 261	+.01	+.02	ZA-064 (Flt. Test)	+.02	-.09	-.08	29	28
PBY-5A	-.12	Galcit 261	+.01	+.02	ZA-064 (Flt. test)	+.02	-.09	-.08	29	28
PB2Y-3	-.18	Galcit 269	+.02	+.04	Est. From ZA-064	+.05	-.11	-.09	32	30

BY

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Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Aero Memo #474
July 29, 1944.

Mr. T. P. Hall
Mr. M. A. Garbell

Wind Tunnel Tests of a 0.058 scale powered wind tunnel model of the thin wing Two-Engine Tailless Navy Design.

Enclosure (A) Plotted Data on Static Longitudinal Stability Flaps Up.

Wind tunnel tests of a 0.058 scale powered wind tunnel model of the thin wing Two-Engine Tailless Design (Aspect Ratio 12, Maximum wing root thickness 17%) have been in progress at Galcit since July 27, 1944. The purpose of the test is the determination of the general aerodynamic characteristics of this design with the revised wing. To date, power-off tests flaps up, including tuft photographs, have been completed.

Preliminary data indicates the same degree of static longitudinal and directional stability for this model as obtained on the previous 0.058 scale model of the tailless design incorporating the 22% thick wing (Enclosure (A)). Power tests are now in progress and the first data should be available during the first part of the coming week.

M. A. GARBELL.

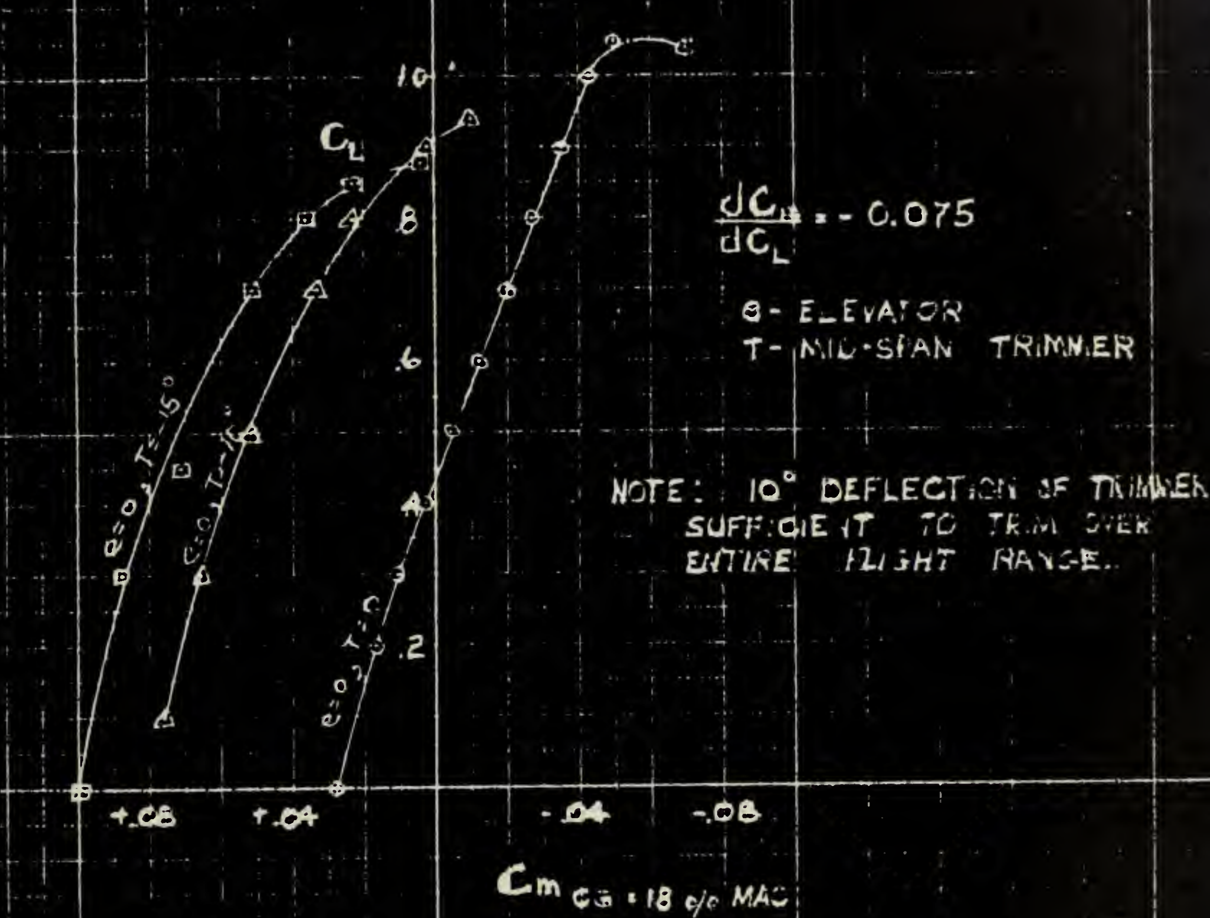
WES/lks
Aerodynamics Offc. #16
Dev. Engr. File

[In margin]: Filed, Hall.

PRELIMINARY DATA

THIN-WING TWO ENGINE TAILLESS NAVY DESIGN

COMPLETE MODEL
FLAPS UP - POWER OFF



Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Ref.—Memo #2423
August 2, 1944

Mr. C. F. McCabe
Mr. T. P. Hall

Pressure Distribution—XB-32 Airplane.

(a) Aero Doc. #33-119 dated July 20, 1944. XB-32—Consideration of Pressure Distribution Measurements in Flight.

Enclosure (A) Copy of reference (a) to addresses only.

Mr. Sutton this date approved the referenced report and requested that we proceed with obtaining pressures as shown therein.

T. P. HALL,
Chief Development Engineer.

TPH/dmc

cc: R. L. Bayless
J. B. Jewell
C. B. Carroll
C. A. Phillips
D. K. Friday
Dev. Engr. Files

August 3, 1944 — To Garbell for work — not scheduled.

[In margin]: Garbell work to follow no schedule.

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
San Diego Division

Page 1 of 6

Model 33 Airplane Report No. Aero Doc. #33-119

July 20, 1944

XB-32

Consideration of Pressure Distribution
Measurements in Flight

1. Wing

The possibility of determining the character of the airflow over the wing, in the region of the nacelles, by measurement of spanwise and chordwise pressure distributions have been studied. Available information indicates that pressure distribution data alone will not show up areas of flow separation. Figure 1 shows pressure and force data for a 66,2-414 airfoil section. The break in the lift curve at 6° angle of attack indicates trailing edge flow separation; however, the chordwise pressure distribution does not indicate this condition except possibly at 12° angle of attack where some loss in lift occurs over the trailing edge where the flow separation is very pronounced. The association of trailing edge flow separation with the break in the lift curve is based on previous tuft tests of the NACA 66 and 65 series sections.

As part of this study, a pattern for pressure orifices on the wing was laid out as shown by Figure 2. These orifices substantially cover the critical portion of the wing with a minimum num-

Defendants' Exhibit B—(Continued)

ber of pressure lines. An alternate method of obtaining pressure data is described in NACA report "The Belt Method for Measuring Pressure Distribution" dated February, 1943. This method requires the construction of a ¾″ wide pressure belt containing approximately 20, .040″ dia. copper tubes. The belt would be placed at about four spanwise stations on four different flights. This alternate method saves considerable work as compared to placing pressure orifices in the wing and also has the advantage of being readily adaptable to other areas if desired after analysis of the first preliminary data.

Pressure tests with this belt in conjunction with tuft observations should indicate the value of pressure data in determining the character of the flow. The tufts will show up the areas of flow separation or stall and it can be definitely determined if corresponding indications are present in the pressure distribution.

If the pressure data appear to be useful, a series of measurements may be made for several speeds varying from high speed to minimum cruise in level flight by 10 mph increments including climb with rated power. These data would be plotted as spanwise and chordwise distributions for study.

2. Fuselage

Pressure distribution measurements have already been made over the bomb bay doors of the XB-32 in flight as given in report ZA-33-023. Page 10 from this report is attached as a sample of the data obtained in these tests.

Defendants' Exhibit B—(Continued)

Other desirable pressure data on the fuselage may be obtained by installation of 16 pressure orifices around the pilots' enclosure, 6 orifices over the nose wheel door and 3 orifices on the fuselage side, as shown by figure 3. The data for the pilots' enclosure and the nose wheel door will be used to check structural analyses. The 3 orifices on the fuselage side will be used to investigate a position for a static orifice for the airspeed indicator. Pressure measurements may be recorded during other flight tests or a flight program similar to that proposed for the Model 39 in report ZA-39-021 may be used.

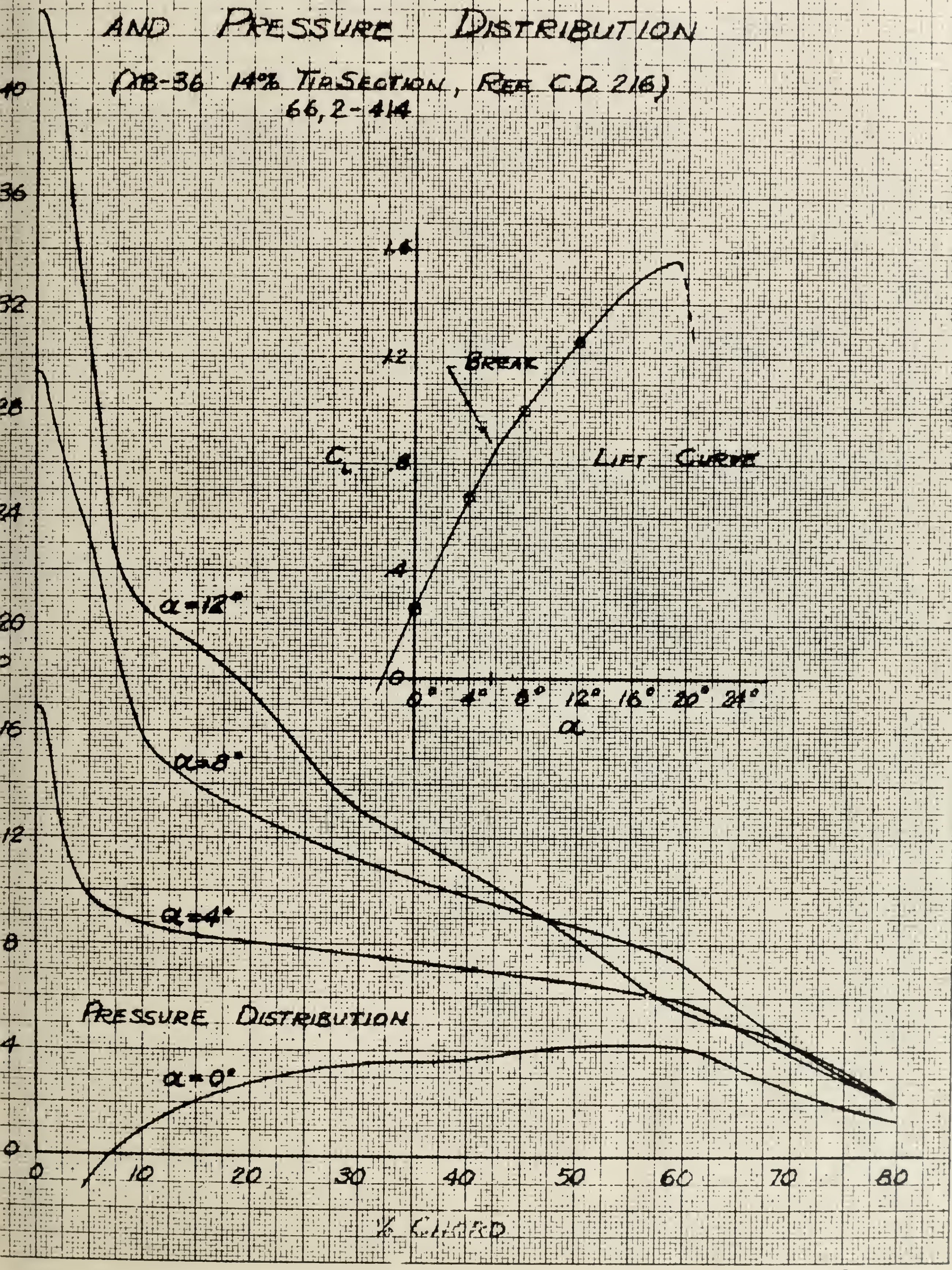
By /s/ C. L. BLAKE.

Checked /s/ BAYLESS.

Approve ....

EFFECT OF SEPARATION ON LIFT CURVE AND PRESSURE DISTRIBUTION

(XB-36 14% TIP SECTION, REF C.D. 216)
66,2-414



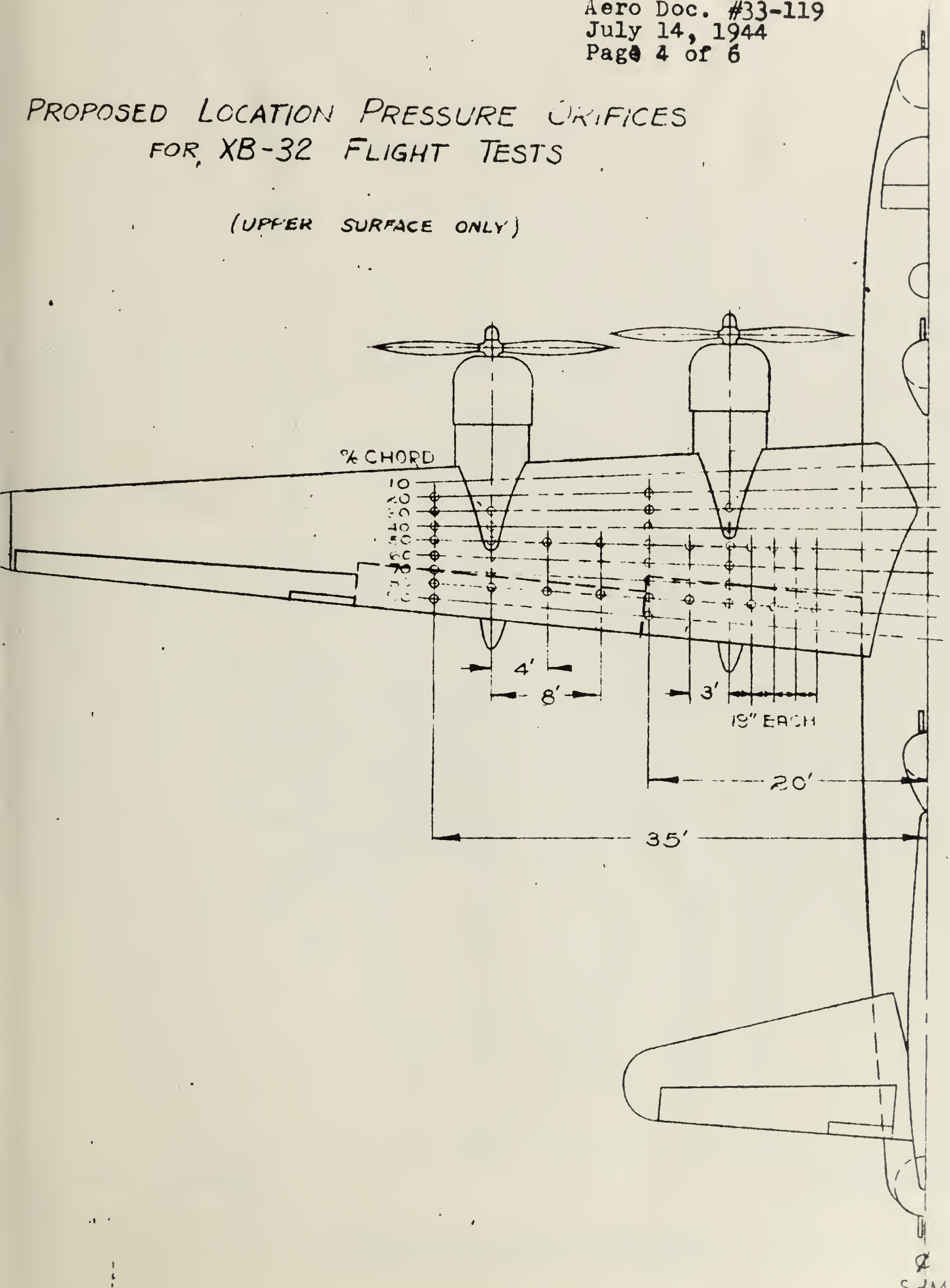
BLAKE
7/18/44

FIG. 2

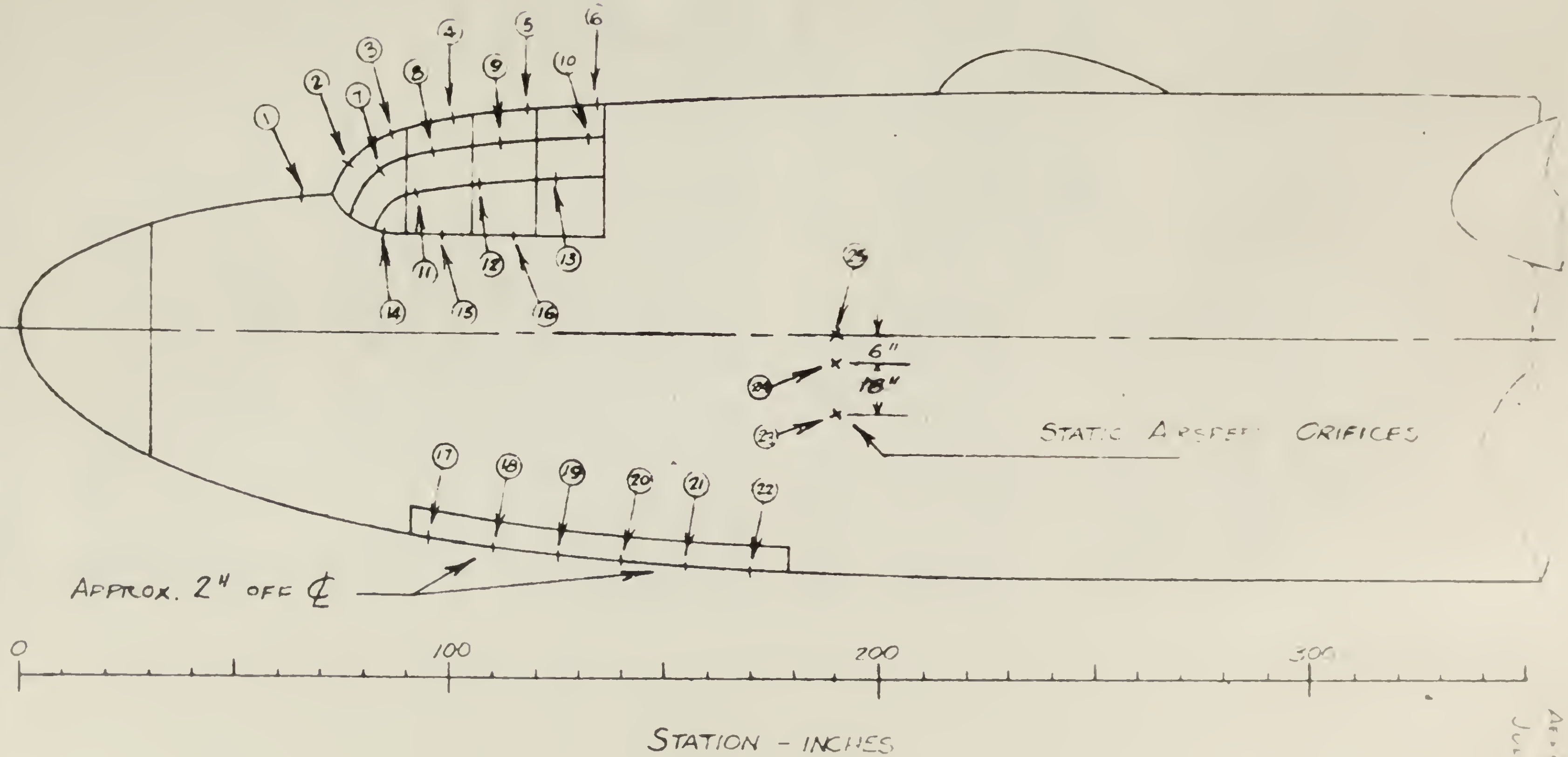
CONSOLIDATED VULTEE AIRCRAFT CORP.
SAN DIEGO

PROPOSED LOCATION PRESSURE ORIFICES FOR XB-32 FLIGHT TESTS

(UPPER SURFACE ONLY)



PROPOSED PRESSURE TUBE LOCATIONS
FOR XB-32 FUSELAGE



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CONSOLIDATED AIRCRAFT CORPORATION
LINDBERGH FIELD • SAN DIEGO, CALIFORNIA

PART NUMBER

Defendants' Exhibit B—(Continued)

Intra-Company Correspondence
Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Aero Memo #481
Date 6 August 1944

From: Mr. T. P. Hall

Subject: Mr. M. A. Garbell

Reference: Preliminary Comments on Wind-Tunnel Tests of 0.058 Scale Powered Model of Two-Engine Tailless Design (Aspect Ratio 12, Thin Wing)

Enclosure: (A) Summary Table of Aerodynamic Characteristics

A .058 scale model of the two-engine tailless design was tested with and without running propellers and with no airflow through the nacelles. This new, higher-speed version of the design compares favorably with the thick-wing version tested at Galcit and M.I.T. (ref. CVAC Report ZT-029 and Appendices). As no tunnel tares were made for these tests the drag values obtained are not reliable. The new thin aft extendible surface is inadequate because the modified aft-surfac airfoil did not equal the high-lift characteristics of the one previously tested.

The model should be reworked before it is sent to Moffett Field. Suggested construction changes are being analysed and the final recommendations will be given to the model shop as soon as possible. The model should be ready to go to Moffett Field at the end of August.

Preliminary Galcit plots of the tests should be

Defendants' Exhibit B—(Continued)

available at San Diego by the 10th or 11th of August. The data on the following summary table of the test results were obtained during the test and are unchecked. A report will be written within a week after the Galcit data reach San Diego.

[In margin]: File misc. Pl. don't return to T. Hall.

/s/ MAG.
M. A. GARBELL.

MR:hes
cc: Aerodynamics
Devn. Engr. File

[In margin]: Memo.

[In margin]: Memo tail camber status.

HAS from TPH.

Enclosure (A)
Aero Memo #481

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

SUMMARY TABLE OF AERODYNAMIC CHARACTERISTICS

		Flaps 0°	Flaps 40°
aximum Lift Coefficient max (ΔC_L = 0.6 added for extrapolation to full scale)		1.6	2.3 Same
atic Longitudinal Stability rivative dC_m/dC_L G. @ 18% Flaps up G. @ 19% Flaps down	Props off	-.074	--
	Windmilling Power	--	-.130
	Cruise Power (.40 NRP)	-.040 was -.05	--
	Normal Power	-.030	--
	Take-off Power	--	Data not yet Available
atic Directional Stability rivative, $dC_n/d\psi°$, (props off)		-.0006 Same	Data not yet Available
d-span trimmer effectiveness m/dδt°	Props off	-.0055	--
	Cruise Power (.40 NRP)	-.0055	---
	Normal Power	Data not yet Available	--
evator effectiveness, m/dδe°	Props off	Data not yet Available	--
	Props Windmilling	--	Data not yet Available
	Cruise Power (.40 NRP)	-.0016	--
	Normal Power	--	--
	Take-off Power	--	Data not yet Available
an Efficiency, "e", between , = 0.3 & C_L = 0.6 (high speed & cruise)		.925 better	--
leron Control Criterion b/2V (obtained with no change in trim) ruise power (.40 NRP), with full control eflection ± 20° aileron and spoiler		.08 Same	--

July 10, 1944
MODEL 32 AIRPLANE REPORT NO Aero Doc. #32-109

Revised August 18, 1944

B-24D

TAIL LOADS IN LEVEL, UNACCELERATED FLIGHT

Figure 1 shows the tail loads for the B-24D in level unaccelerated flight between high speed and the speed for maximum range. loads are positive (i.e. up) except for high speed at very low ght. The data are shown for 25,000 ft.

Figure 2A shows the tail loads in terms of (tail load/q) tted vs. C_L. Figure 2B shows the pitching moment vs. C_L with tail . The tail load is computed from the unbalanced pitching moment follows:

$$\text{Tail load (lbs.)} = \frac{C_m S C q}{l_t}$$

Where S = wing area = 1,048 sq. ft.

C = MAC = 10.3 ft.

l_t = tail length = 36.5 ft.

q = dynamic pressure

$= .00256\ V_i^2$

Where V_i = true indicated airspeed in mph.

Figure 3 shows C.G. data for the B-24D. A value of 32% assumed to be representative for the computation of tail loads.

Figure 4 shows C_L vs. true indicated airspeed for several ghts. These data are for reference only.

STATIC LONGITUDINAL STABILITY IN LEVEL, UNACCELERATED FLIGHT

The actual value of the tail-loads has no effect on the gitudinal stability of the airplane. The important element is the l-load slope. With increasing angle of attack the tail-loads on B-24 airplane increase in a positive (up) sense, thus producing ater diving moments; this variation is stable as shown in Fig. 2 B.

BY Magaziell

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STRUCTURAL CRITERIA FOR TAIL LOADS

The B-24 tail surfaces are designed for the loads arising in four principal flight conditions as follows:

1. Balancing loads at the four corners of the V-g diagram, i.e. the design load factor at

   (a) High angle of attack (up tail load)
   (b) Low angle of attack (up tail load)
   (c) Inverted flight, high angle of attack (down tail load)
   (d) Inverted flight, low angle of attack (down tail load)

2. High speed, one -"g" flight with a 30 ft/sec. up or down gust. (Tail load up or down depending on direction of gust.)

3. Pullout (tail load first down and then up).

4. Placard speed with flaps down and 30 ft/sec. gust (tail load down).

The B-24 tail is designed by the critical up and down tail loads. The tail loads for other designs may be in the opposite sense in some cases depending on the design conditions.

BY

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CONSOLIDATED VULTEE AIRCRAFT CORPORATION
GENERAL OFFICES . . SAN DIEGO, CALIFORNIA

Aero Memo #537
October 10, 1944

Mr. T. P. Hall

Mr. C. L. Blake

Current Wind Tunnel Tests on the 2-Engine Executive 1/8-Scale Preliminary Power-Off Model at Galcit.

Enclosure: (A) Aero Doc. Misc. #138 dated October 10, 1944.

The attached sheets show a summary of the tests to be conducted and sketches of the various fillets to be tried in selecting the basic airplane configuration.

C. L. Blake

JP:jm
cc: Dev.Engr.File
Aero ...

The wing referred to as the "44" wing is actually ... following ... airfoils ...

... 10/17/44

Defendants' Exhibit B—(Continued)

1 of 2

Consolidated Vultee Aircraft Corporation
General Offices San Diego, California

Aero Doc. Misc. #138
October 10, 1944

Test Outline 2-Engine Executive
1/8 Scale Wind Tunnel Model

1. Strut tares and flow inclination determination——

a. Wing alone, NACA 44 and 63 section wings.

b. Complete model using each wing.

2. Wing alone study: Selection of either the NACA 44 or 63 section wing.

a. Tuft studies—stall hysteresis analysis.

3. Model build-up drag analysis.

4. Flow investigation near Wing - fuselage, Wing-Nacelle and Fuselage-tail intersections. Tests of necessary fillets to improve flow conditions will be made.

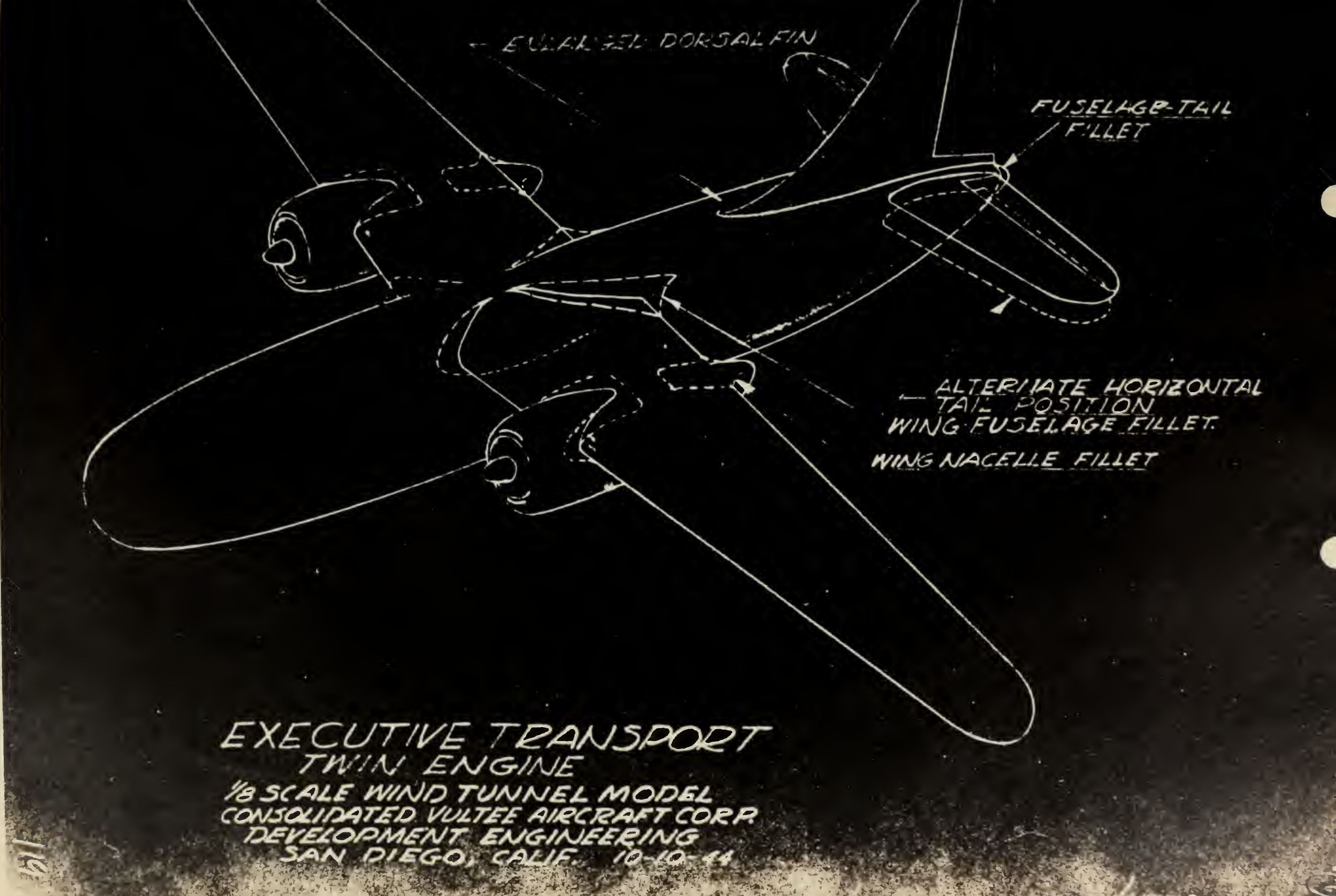
5. Total head survey, with flaps extended and retracted, to locate best tail position.

6. Longitudinal stability and control, elevator effectiveness, flaps zero and fully deflected for final selected wing and complete model including fillets (and tail off).

7. Directional stability and control, rudder effectiveness for complete final configuration flaps 0° (and tail off).

8. Stabilizer effectiveness using both wings.

9. Test of a larger dorsal fin.


ENLARGED DORSAL FIN
FUSELAGE-TAIL FILLET
ALTERNATE HORIZONTAL TAIL POSITION
WING-FUSELAGE FILLET.
WING NACELLE FILLET
EXECUTIVE TRANSPORT
TWIN ENGINE
1/8 SCALE WIND TUNNEL MODEL
CONSOLIDATED VULTEE AIRCRAFT CORP.
DEVELOPMENT ENGINEERING
SAN DIEGO, CALIF. 10-10-44

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
San Diego, California

Page 1 of 4

Aero Doc. Misc. #142
November 3, 1944

Model Airplane Report No.

Comments on Stinson Report No. 1551
Series II Wind Tunnel Test of 1/5 Scale

Powered Model Single Engine Pusher Design
(Reference: MIT Report #651)
October 14, 1944

A study of the subject report indicates that, despite the installation of the large leading-edge slot, the stalling characteristics of the airplane remain unsatisfactory, especially with flaps deflected. This is particularly borne out by the data plotted in figure 14 of the subject report (figure A attached to this Aero Document), which shows that even a small deflection of the elevator causes a breakdown of the airflow about the wing and a loss of lift of $\Delta CL = -0.4$. A typical satisfactory airplane is shown, for comparison, in figure B. The airflow conditions with flaps retracted are also unsatisfactory as indicated by the following test material:

1) Figure 11 (page 19)—Most curves show objectionable discontinuities in the static longitudinal stability slopes.

2) Figure 13 (page 21)—The sharp variations of the rolling and yawing moments, as well as side forces, indicate asymmetric local stall phenomena which would contribute to make the stall of the airplane vicious and diffi-

Defendants' Exhibit B—(Continued)

cult to control. A comparison with the characteristics of the original model with the leading-edge fillet, shown in figure C, indicates a deterioration in this respect.

3) Photograph on page 49—Despite the installation of the large slot, a distinct cross flow appears between the fuselage and the tail booms, indicating the existence of turbulent separation at the wing-fuselage intersection.

Conclusion:

The new model with the slotted inboard panel shows no substantial and consistent improvement over the optimum previous model configuration with the leading-edge fillet which was not considered a satisfactory basis for further design and construction work. The drag difference of .0010 between slot and leading-edge fillet is not representative of the actual drag difference between the two modifications, because of the high surface drag of the leading-edge fillet which consisted of a basic wood structure and a large amount of plasticene.

By /s/ M. A. GARBELL.

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
San Diego, California

Page 1 of 2
Aero. Doc. # TL-105

December 26, 1944

Model........ Airplane........ Report No.......

Preliminary Proposal for a Scale Model of the Two-Engine Tailless Airplane

The construction of a scale model of the two-engine tailless airplane, large enough to accommodate a pilot as well as a radio control and recorder, is proposed to obtain additional information on the stability and control characteristics of the tailless design at a scale which approximates more fully that of the actual airplane. The model should be tested in free flight and as a static wind-tunnel model in the "full-scale 80′ x 40′ tunnel" at Moffett Field.

It is proposed to use existing Navy radio equipment if radio controlled flight testing is desired.

Model Characteristics
0.4 Scale—No Power

This model, geometrically similar to the full-scale design, would yield valuable information on stall, stability and control characteristics at a high Reynolds number as well as the "feel" of the airplane,

Defendants' Exhibit B—(Continued)

and would permit the investigation of the most desirable path and hinge moments of flaps and control surfaces. It would also serve to study and develop additional means of obtaining greater directional stability at a minimum cost and risk.

General Data

Scale	0.4
Span	58.8 ft.
Wing Area	288 sq. ft.
Fuselage Diameter	41.6 in.
Gross Weight	1440 lb.
Type of Construction	All wood

Consolidated Vultee Aircraft Corporation
San Diego, California

Page 2 of 2

Aero. Doc. #TL-105
December 26, 1944

Model Airplane Report No.

Estimate of Man Hours

Item	Man Hours
Structural layout and design	
4 men for 4 weeks	800
Structural analysis	
1 man for 4 weeks	200
Shop time (mostly in model shop)	
12 men for 10 weeks	6,000
Total	7,000

Defendants' Exhibit B—(Continued)

This number of man hours is equivalent to that of two power-off wind-tunnel models of much smaller scale.

Provisions should be made to incorporate fittings for the balance of the Moffet Field "full-scale" tunnel.

Any airplane of the 100-150 HP class will be sufficient for towing this model.

Additional Consideration

If the power off tests give reliable and encouraging data, it is suggested that the tests be extended to include a dynamically similar 0.4 scale model powered with two Lycoming 0-290 engines (130 BPH each which will simulate full take off power). This model would be suitable for complete wind tunnel and flight tests and for presentation to the trial boards of potential customers.

By /s/ M. A. GARBELL.

MODEL AIRPLANE REPORT NO Aero. Doc. #TL-106

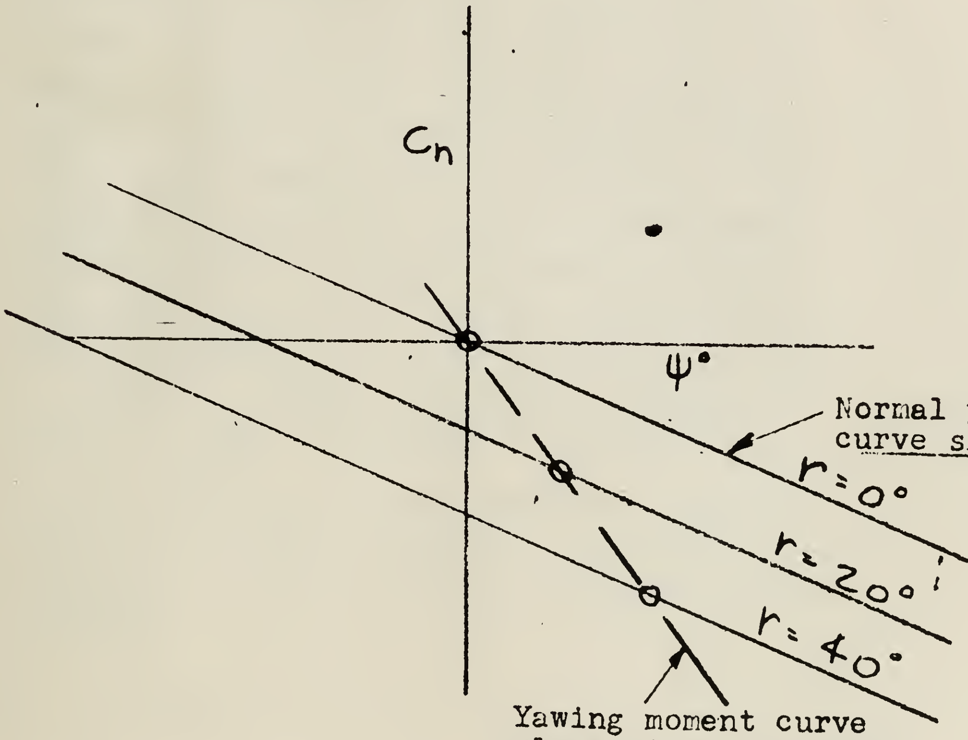
December 26, 1944

TWO ENGINE TAILLESS

Study of Means to Increase

Directional Stability

Theoretical studies show that increased static directional stability may be obtained by use of a horn balance or a large leading edge balance which will produce overbalance of the rudder in yaw. The resulting anti-trail of the rudder will increase the static directional stability as shown below.



The inherent fault of the above system is the hunting characteristic for which no satisfactory corrective means has been determined.

The static directional stability may be increased also by enlarging the wing tip surfaces; however, it does not appear feasible to increase the area of these surfaces beyond 15% of the wing area (Note: Present two-engine tailless design has 12% surfaces). The resulting $\frac{dC_n}{d\psi^\circ}$ would be only -.0008 with 15% surfaces as compared to the present -.0006. This value is about one-half of the $\frac{dC_n}{d\psi^\circ}$ for the PB4Y-2 and B-32.

BY M.A. Gartell

CHECKED

APPROVED

Consolidated Vultee Aircraft Corporation
San Diego, California

Page 2 of 2

Aero. Doc. #TL-106
December 26, 1944

Model . . . . Airplane . . . . Report No.

Two Engine Tailless

An effective increase in the directional stability may be obtained by an increase in the directional damping of the airplane. This may be accomplished by connecting the rudder control permanently to the yawing velocity channel of the automatic pilot. The rudder will automatically counteract a tendency to yaw by building up a restoring moment at a rate equal to the magnitude of the disturbance. The resulting effect will be to increase the directional stability in the same manner as would be obtained with greater fin area. It has been calculated that this arrangement can be adjusted simply to give a directional stability equivalent or possibly superior to a $\frac{dCn}{d} = -.0018$ which is representative of current conventional airplane design. This arrangement may be tried on a twin tail B-24 to determine the degree to which the directional stability can be improved.

Defendants' Exhibit B—(Continued)

Consolidated Vultee Aircraft Corporation
San Diego, California

Page 1 of 15

Model .... Airplane .... Report No.

Aero Doc. # Misc. 192
May 10, 1945

Report on
Conferences at Ames Aeronautical Laboratory
Moffett Field, California

May 4, 5, and 7, 1945

A series of conferences were held at the Ames Aeronautical Laboratory, between representatives of NACA and CVAC, on 4, 5 and 7 May 1945, to discuss the forthcoming tests of the XB-46 design in the Moffett Field wind tunnels and to exchange opinions and ideas on certain aerodynamic high-speed problems relating to this design.

NACA Representatives

D. H. Wood
C. W. Frick, 7′ x 10′
R. Jackson, 7′ x 10′
M. J. Hood, 16′
W. T. Hamilton, 16′
J. Allen
(Others were met in informal conversations)

CVAC Representatives

M. A. Garbell, Development
G. L. Shue, Aerodynamics, San Diego

By /s/ M. A. GARBELL.

SUMMARY OF SUBJECTS DISCUSSED

I. 7' x 10' Wind-Tunnel Test of 0.075-Scale Power-on Model.

1. The wind tunnel will be available for testing the XB-46 model beginning 21 May 1945.

2. NACA expects to start the test 2 weeks after arrival of the model at Ames Aeronautical Laboratory (Estimated 15 May 1945).

3. The test period is expected to last for 3-4 weeks.

4. Model drawings should be sent to NACA at once, for inspection and structural check.

5. Jet unit should be sent to NACA at once, for bench test alone and in conjunction with rear-strut attachments.

6. Use data at various $\frac{v}{V}j$ ratios to obtain "power-off" and "idling power".

7. Comments on CVAC test program (Aero Doc. #109-114, Revised May 1, 1945):

   a. Ref. I, A (Purpose): A new AAF Spec. C-1815a is being distributed to replace Spec. C-1815.

   b. Ref. I, D (Tests), par. 1: Tab effectiveness should not be included on this small model.

   c. Ref. I, D (Tests), par. 5. Omit this test, use cross-plots of hinge-moments instead.

8. NACA is fully equipped to take tuft movies if necessary.

9. Small lift and pitching moment tares with jet-power-on are anticipated (approx. 2 lb. ΔL and 0.5 ft. lb. ΔM).

10. Perfect alignment of all control-surface hinges is an absolute prepequisite to the attainment of good hinge-moment data.

11. NACA recommends that the nacelles be painted in the customary manner despite the fairly high temperatures of the primary jet air.

BY________

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12. It was agreed that the tests be commenced with the ground board runs, power on and power off, in order to determine the adequacy of the horizontal tail and the behavior of the jet close to the ground. Great importance is attributed to this phase of the test, the first of its kind ever performed on a multi-jet design.

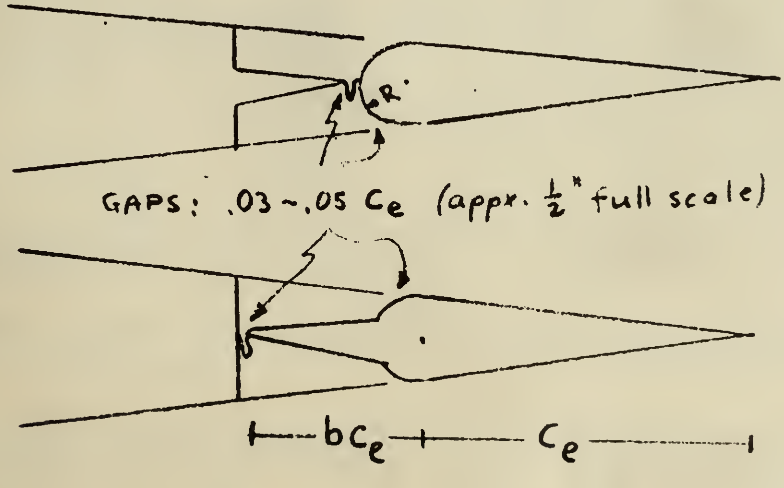
7' x 10' Wind-Tunnel Test of 0.3-Scale Semi-span Horizontal Tail.

1. This test is expected to start approximately 4 weeks after the start of the 0.075-scale model test, and to last approximately 2 weeks.

2. Drawings should be completed and sent to the NACA as soon as possible. Actual construction of the model, however, should await the results of the ground-board test of the three-dimensional model.

3. The model must have steel spars in both the stabilizer and elevator and must be designed for q = 80 lb/ sq.ft. (ultimate load factor 5).

4. Two alternate internally sealed nose balances (see sketch below) shall be tested to provide means of calculating the characteristics of any intermediate balance.



Nose balance scale consisting of dental dam as enclosed here will be furnished and installed by NACA, but CVAC must

provide for means of installation. The seal gap should be very small to avoid non-linear jumps in the hinge-moment curve.

Balance cell pressures shall be taken at four span-wise stations.

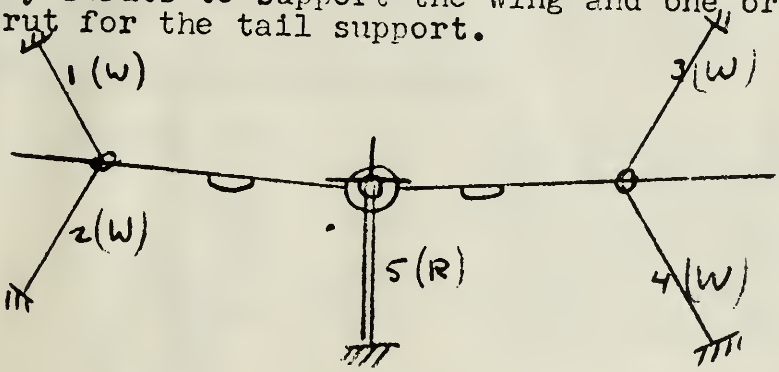
5. External pressure tubes shall be taken on both sides of the airfoil and shall extend as close as possible to the trailing edge.

6. Control tabs shall be aerodynamically balanced. The NACA prefers to install their own hinge moment strain gages; CVAC, however, is expected to install the electric leads from the tab strain gage location to the elevator torque tube and along the torque tube center line through the wind-tunnel wall.

I. 16' Wind-tunnel high-speed test of 0.09 Scale power-off Model

1. At present, the 16' high-speed tunnel is scheduled for high-priority tests through 15 September 1945.

2. The new suspension system consists of four tension-only struts to support the wing and one ordinary strut for the tail support.



This new system eliminates local choking at moderately high Mach numbers.

3. The wing cannot be supported without faired bumps at the trunnions.

4. Yawing and rolling moments are not accurately measured with this suspension system. High-speed vertical tail characteristics must be determined from pressure distribution data in the Co-op tunnel.

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5. The tail trunnion must be accessible both up and down for tare runs with the vertical tail off.

6. The principal problems arising in all tests in the 16' high-speed tunnel are:

   a. buffeting and shaking of the models, especially at high speeds.

   b. a very large temperature range, affecting the strain gage readings.

   c. the ample range of q's.

7. Specifications for strain gages:

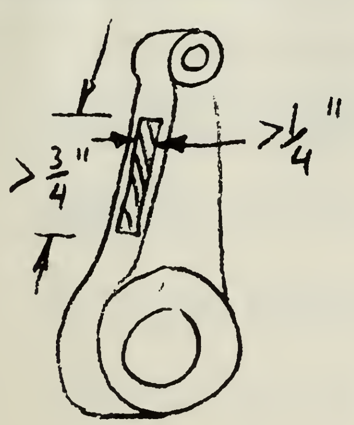
   working stresses (with ultimate load factor 5)

	Steel	Al. Alloy
Bending gages	S_f = 32,000 lb/sq.in	S_f = 12,000 lb/sq.in
Torsion Gages	S_f = 17,000 lb/sq.in	S_f = 7,000 lb/sq.in

All strain gages should be supplied at least in duplicate

8. Minimum size of strain gages:

   a. Bending gages



Approximately constant-stress beam (with straight sides). Strain gages on both sides forming the opposite branches of the bridge in order to minimize temperature effects.

   b. Torsion gages:

   1/8" diameter 1/2" length

9. Angle indicator drives must have their own link systems not attached to the strain gages. Temperature effects should be eliminated by connecting all four branches, or by using selsyn drives (for example, Kollsman #845-01).

10. All hinges must be perfectly aligned and must be built very sturdily to resist the considerable shaking of all control surfaces at large deflections. Control surfaces must be mass balanced.

11. Remote-control drives and position indicators should be considered to replace manual positioning. The desirability of the various remote controls is expressed by the following order of priority:

    1. elevator
    2. rudder
    3. ailerons (if possible)

    Special note on elevator and rudder: One actuating motor (for example, a Learavia actuator) located far ahead inthe fuselage (perhaps in the bomb bay) to avoid interference with the tail trunnion, may alternately drive the elevator and the rudder merely by switching the driving links.

    The two elevator halves may be controlled separately; hinge moments may then be measured on one semi elevator, while the other semi elevator is used for pressure distribution measurements.

    All actuating mechanisms must be very rigid.

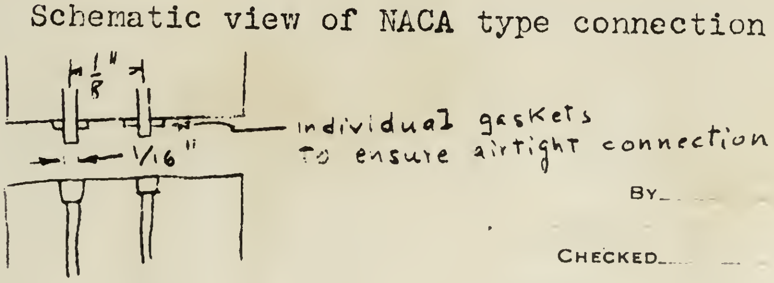
12. Notes on pressure distribution measurements.

    a. Approximately 150 tubes can be easily accommodated simultaneously (more if necessary).

    b. Four wing pressure distribution stations should suffice.

    c. All copper tubing must be annealed to avoid cracking.

    d. Schematic view of NACA type connection plugs:



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13. Note on induction air flow through nacelles:

No powered blower is needed for $\frac{v}{V}$ up to approximately 0.8. Baffle plates should be provided for lower inlet-velocity ratios.

14. Notes on CVAC preliminary schedule:

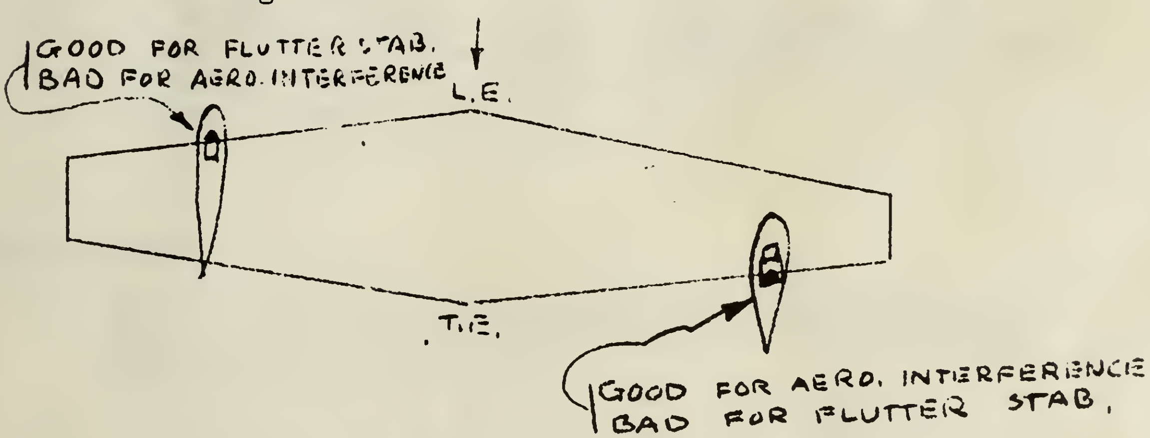
a. Three stabilizer settings are considered to be fully adequate.

b. Gear hinge moments should be measured with the landing gear extended (it is also suggested that an outside pressure distribution on the tires be run, if the landing gear is to be extended at high speed).

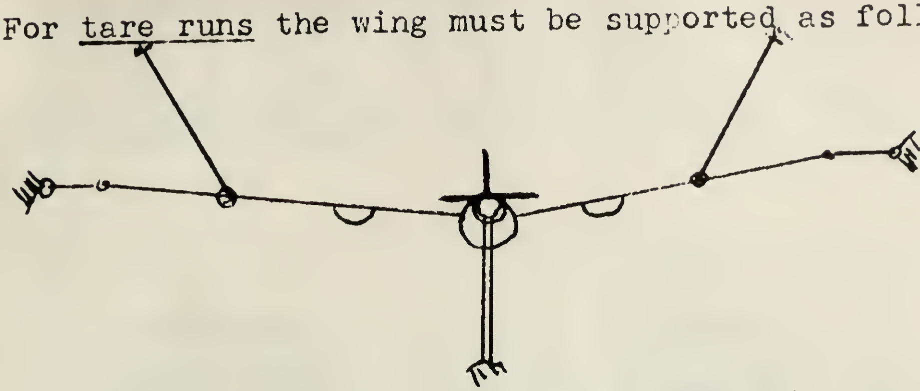
15. The stress analysis of the model should be based on the following design conditions:

$q = 800$ lb/sq.ft.
M in excess of 0.85
$n_{ult} = 5$

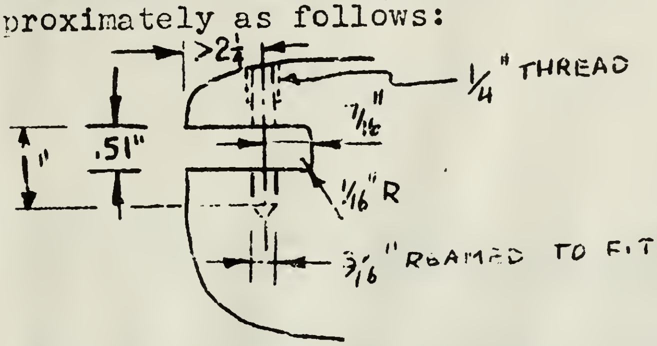
This will necessitate an all steel wing (or similar strong material). A complete flutter analysis will be required by NACA. The two extreme solutions for the design of the wing support trunnion are shown in the following sketch:



16. For tare runs the wing must be supported as follows:



The two thin tie-rods intended to restrain any lateral motion of the model require fittings in the wing approximately as follows:



17. The NACA is equipped to take tuft movies. The interference of the bumps at the strut-wing intersection, however, will reduce the significance of any tuft studies greatly.

IV. Wing Airfoils

1. No serious objection against the "straight-sided" fairing of the XB-46 wing airfoils was voiced by any NACA representative.

2. No information on the physical laws governing the development of two compressibility shock fronts on an airfoil in the deflected flap (aileron) is available.

3. NACA representatives have no knowledge on optimum flap gaps for thin 65 sections. A new Memo Report for Bauer on 66₁-216, a = 0.6, with flaps, by Holtzclaw, shows an optimum chordwise position of the flap 2% ahead of the physical wing trailing

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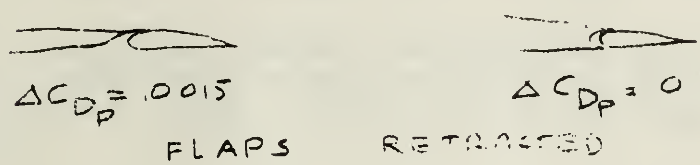
edge (same as our Galcit test) but indicates larger and less critical gap values. At RN = 5 x 10^6 the BuAer test shows the same C_{Lmax} with flaps deflected for the following two configurations:



V. <u>Tail airfoils</u>

1. The following fairly recent report, not available at CVAC, should yield the needed information:

   Henry Jessen: The Effect of Various Horizontal Tails upon the High-Speed Longitudinal Control of the P-51B Airplane from Wind Tunnel Tests. NACA CMR for AAF, 24 June 1944.

   Also request preliminary data on a P-47 test with spoilers on the horizontal stabilizer from the Army.

2. It was agreed that a 64_1 - 010 or 64_1 - 011 should replace the 66_1 - 010 <u>airfoils</u> on the XB-46 <u>tail</u> surfaces, in order to minimize the adverse compressibility effects due to control surface deflections and to reduce the sensitivity of the tail surface airfoils to surface roughness. (It may be necessary to maintain higher-than-static pressures inside the movable surfaces in order to minimize hinge-moment troubles due to skin deflection. M.A.G.)

3. No data on $\frac{\Delta V}{V}$ due to control surface deflection are available for the 64 airfoils. Some information may be gleaned from J. Allen's TR 637. Allen also suggests that these increments may be estimated from the increments measured on the 66_1 - 010 airfoils by using the following expression:

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$$\left(\frac{\Delta V\delta}{V}\right)_{64} = \left(\frac{\Delta V\delta}{V}\right)_{66} \frac{\left(\frac{V}{V_0}\right)_{64}}{\left(\frac{V}{V_0}\right)_{66}}$$

This expression neglects the change due to difference in airfoil thickness at the control surface hinge line.

4. The 64 section may require more nose balance than the 66 section because of its smaller T.E. Angle.

5. NACA recommends ribbed construction on balance shroud with balance nose notches to clear, thereby permitting greater deflections with large balance noses.

6. NACA recommends tests with 0 and 40% balance, with pressures taken in the balance cell.

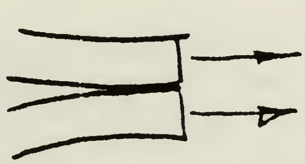
I. Effect of Jets on Longitudinal Stability

1. NACA recommends use of the method by Squire and Trouncer presented intheir report on "Round Jets in a General Stream".

2. Our own estimate of $\Delta \frac{d\ C_m}{d\ C_L}$ due to the jets = 0.08 is found to be slightly conservative. Measured values on similar models were between 0.04 and 0.05.

I. Interference between Jets

1. Although no experimental data are available at NACA, it is generally agreed that a parallel arrangement of the jet exhaust stacks



is preferable to the convergent arrangement.

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Nacelles and Ducts:

1. Attention of the NACA representatives was drawn to several incorrect assumptions in the nacelle designs of TSESE-41, such as 65-inch total nacelle height for the 65-inch wheel, the excessive width of the NACA nacelle, and the retention of the cooling shroud ahead of the turbine.

2. The NACA has found that there is no need for pressure relief doors in the air intake ducts. On the basis of previous experimental data they estimated an efficiency of 95% for our duct, even at stand-still.

3. The NACA nacelle designs have shown good duct characteristics with one unit inoperative.

4. A report on the optimum lip shape is being released. Comments on the CVAC type nacelle forebody were quite favorable, except that the lip radii and the separator-lip radius should be approximately doubled in order to minimize angle of attack effects, and the effective yawing angle existing during one-unit-inoperative operation.

   NACA representatives agreed warmly with the CVAC air intake duct (Ref. Aero Doc. 109-115) and especially with the conservatism shown in the slow initial expansion close to the intake leading edge where separation due to high angles of attack may occur most readily.

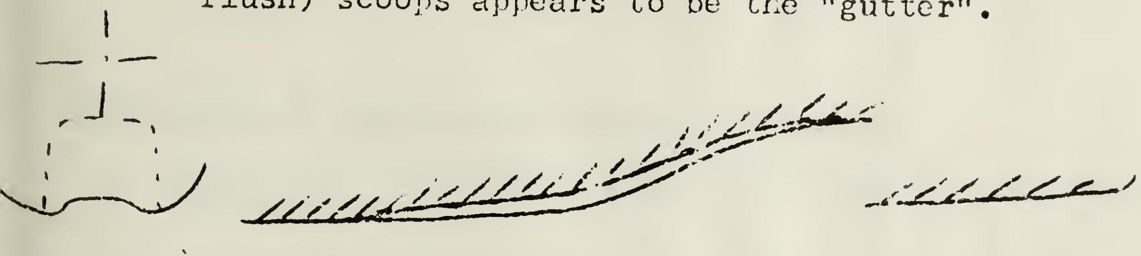
5. NACA recommends that we introduce a rake of hypodermic needle total-head tubes at the location of the blower to determine the ram efficiency of the intake duct, and another set at the jet exit to measure the total drag losses due to the power-nacelle when running MDP's without power.

6. The Cleveland Laboratory is testing various jet exhaust shapes.

IX. Flush Scoops

1. An NACA report on flush scoops is being written; release is expected within approximately 3 months.

   An important feature of efficient submerged (or flush) scoops appears to be the "gutter".



X. Effect of Nacelles on Span Load Distribution.

1. NACA has observed a shift in zero lift angle of 1° on the two-dimensional section panels with nacelles, i.e. less than our M.I.T. and Galcit values. Our attempts to reduce this undesirable effect by cambering the nacelles are believed to be steps in the right direction.

2. NACA suggests that we measure pressure on lower flanks of nacelles and fuselage to detect mutual compressibility and interference effects.

I. Lateral Control

No new data available pending the release of generalized NACA wind tunnel data.

I. Dive Recovery Devices

1. No recently released reports exist (see item XI).

2. A P-80a pulled to $C_L = 0.7$ at $M = 0.85$ without using any dive recovery devices.

II. Canopy

1. No canopy-wing interference of compressibility shock fronts is expected in the design range of flying speeds because of the favorable shape of the canopy and its great distance from the wing.

IV. Photographs of Compressibility Shock Fronts.

1. Phenomena observed at CVAC are probably condensation fronts.

2. P-51 flight movies at Wright Field were made by Parsoni. Condensation fronts appear there too. Caltech has a print of the movie.

V. Effects of Wing and Tail Shock Fronts on Control Forces.

1. "Walking" of tail controls on P-51 and P-80 results either from irregular chordwise motion of the shock fronts over the control surface or from the variations in downwash aft of the wing resulting from analogous shock-front movements over the wing (M near 0.80).

2. "Buzzing" of ailerons (approx. 200 to 400 cycles per sec) has also been observed on the P-80a airplane in flight at M = 0.76. (Previous 16' wind tunnel observations had indicated a frequency of 20 cycles per sec.)

I. Air Flow through the Bomb Bay at High Speeds.

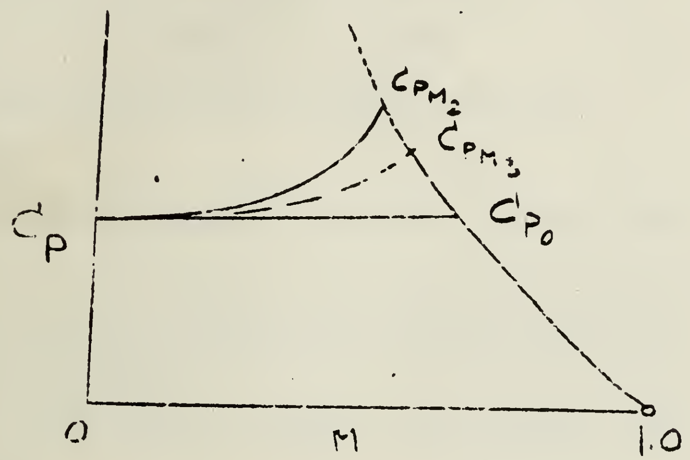
1, NACA suggests that we develop several satisfactory means at low M, before spending high-speed tunnel time on further developments.

2. Mr. Allen has heard from Boeing representatives that some serious troubles have been encountered on the B-29 with bombs tumbling and colliding when released in pairs at high speed. He has seen the newsreels quoted by the Boeing engineers and believes the difficulty to be very real, but does not know what corrective steps Boeing has undertaken.

II. Determination of the Critical Mach Numbers of Three-Dimensional Bodies.

1. In view of the lack of a satisfactory compressibility theory for three-dimensional bodies, Mr. Allen suggests that the critical Mach number of a three-dimensional body be estimated from an increment one-half of the Glauert increment, i.e.

$$C_{P_{M_3}} = \frac{C_{P_0}}{2} + \frac{1}{2\sqrt{1 - M^2}} C_{P_0}$$



I. Availability of NACA Memorandum Reports for AAF and BuAers.

It was remarked that, oftentimes, Memo. Reports for the AAF and BuAer are not issued to CVAC nor are their titles included in the regular NACA lists of reports; that such reports, however, are readily released to CVAC if a specific request, based on information obtained by devious means, is made to the Army or Navy respectively.

NACA representatives are aware of this situation and recommended that CVAC contact Major Jay Auwerter (Army-Wright Field) and Messrs Laudon, Griggs, and Diehl (Navy-BuAer), to have the two agencies make a list of Memo Reports available to CVAC as soon as the reports are released.

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Admitted November 22, 1950.

DEFENDANTS' EXHIBIT D

Consolidated Vultee Aircraft Corporation
General Offices—San Diego, California

Page 1 of 14

December 5, 1944

Effective Control of Stalling Characteristics of Highly Tapered and Swept-Back Wings

By Maurice A. Garbell

Consolidated Vultee Aircraft Corporation

Summary

A tested new method of airfoil selection conceived:

To assist the designer in overcoming present hazardous stalling tendencies on highly tapered and swept-back wings:

To control stall at inception and through progression.

This practicable method eliminates high drag-penalties and other undesirable characteristics which develop with large washout and highly cambered wing tips when employing two controlled sections.

Three controlled sections, one located at the wing root, another at a midspan station, and the third at the wing tip, are connected by straight lines. The principal parameters affecting the maximum section lift coefficient, viz.: the section thickness ratio and camber are chosen to satisfy the section lift coefficients required by the computed span load distribution at the Reynolds numbers of the three spanwise control stations.

Defendants' Exhibit D—(Continued)

The resulting spanwise distribution of maximum lift coefficients permits the designer to exercise close control over the progression of the stall from its inception, and thus reduce washout and camber variation to a minimum. This method also achieves a favorable distribution of critical section Mach numbers along the span. A small but appreciable increase in maximum wing lift coefficients is also obtained.

Reasons for the Study

The need to overcome hazardous stalling characteristics of highly tapered and swept-back wings has given rise to the present study.

An investigation of the fundamental reasons for these unsatisfactory stalling tendencies reveals that the planform taper of the wing creates two unfavorable effects on the stalling characteristics:

1. The highly tapered planform leads to a deviation from the elliptical span-load distribution in the direction of higher loads at the wing tips for a given wing lift coefficient. Sweep back accentuates this phenomenon. (Fig. 1).

2. The decrease of chord length from the root to the tip reduces the Reynolds number and hence the maximum lift coefficient attainable for a given airfoil.

These two unfavorable developments have been universally counteracted by two measures:

1. Aerodynamic washout, that is, washout of the

Defendants' Exhibit D—(Continued)

zero lift angles, produced by twisting the tip chord with respect to the root chord.

2. The employment of a more highly cambered airfoil at the wing tip than at the wing root.

For manufacturing simplicity the corresponding airfoil stations of the root and tip sections are customarily connected by straight lines. The resulting spanwise variation of aerodynamic washout, camber,

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and thickness ratio is hyperbolic inasmuch as they vary as

$$y = \frac{a + bx}{c + dx}$$

Where: a, b, c, and d are constants depending upon wing geometry x is the spanwise station y is the variable to be determined (aerodynamic washout, camber, and thickness ratio respectively).

Typical spanwise variations are shown in Figure 2.

The principal effect of washout consists of a reduction in the loads at the wing tip and an increase of loads inboard, as shown in Figure 3. The resultant improvement in the stalling characteristics, however, is gained at a penalty in induced drag through the prevalance of positive and negative basic lift over the wing span at zero wing lift (Reference 1).

Washout does not change the section maximum-lift coefficients attainable at the various spanwise stations.

Camber and thickness variations do not affect the spanload distribution (if their slight influence on the

Defendants' Exhibit D—(Continued)

section lift-curve slopes is disregarded), but modify the spanwise distribution of the maximum attainable section lift coefficients.

The straight-line variation of airfoil chord also results in a linear decrease of the Reynolds number from wing root to tip. A nearly linear reduction of section maximum lift coefficients along the span, for a given airfoil section, ensues consequently from the typical maximum lift variation with Reynolds number shown in Figure 4.

A typical spanwise variation in section maximum lift coefficient resulting from the linear fairing of a wing root section and a more highly cambered wing-tip section is portrayed in Figure 5. It is evident

that the line of maximum lift coefficients is concave upward and may even have intermediate stations below the two extremes, because the favorable effect of camber (and thickness) following a hyperbolic law is insufficient to compensate for the unfavorable effect of the linearly disminishing Reynolds number.

As a rule the resulting stall pattern is unsatisfactory for any but the lowest taper ratios and may become critical for taper ratios in excess of 3:1 (see Fig. 5). The stall inception close to the wing tip and the comparatively slow progression of the stall farther inboard produce the most undesirable type of stall, with little or no warning, violent rolling moments, and neutral or unstable pitching moments through the stall.

Defendants' Exhibit D—(Continued)

Any attempt to improve these stalling characteristics by flattening the actual span-load distribution through aerodynamic washout, or raising the curve of the available maximum lift coefficients near the wing tips through adequate amounts of mean-line camber, or by both of these measures, introduces a large drag penalty. In addition, the span-load distribution at the high lift coefficients and Mach numbers occurring during pullouts and steep turns is greatly disturbed by a large spanwise variation of camber. The peak pressure coefficients at high section lift coefficients increase more rapidly over the sections with small camber than over those with large camber, and result in a premature shock stall at the inboard sections, followed by an outboard shift of the air load and a consequent increase in the wing bending moment.

The aforementioned inadequacy of the linearly tapered wing with two controlled sections has led to the development of wings with three controlled sections to permit the designer to obtain the desired

stall inception and progression with a minimum of washout and camber variation.

Definition of Desirable Stalling Characteristics

From the pilot's viewpoint a desirable stall is preceded by a gentle but reliable warning in the form of a mild tail shake some 5-10 mph above stalling speed. The stall should be free from sudden roll, aileron snatch, or severe premature tail buffeting and should be accompanied by a rapid negative

Defendants' Exhibit D—(Continued)

increase of the static longitudinal stability derivative, dCm/dCL.

In order to achieve these desirable characteristics it is advocated that stall separation should start approximately at mid-span, outboard of the horizontal tail (to prevent premature tail shake), and should spread, fairly evenly, inboard and outboard, (Fig. 6). The tail shake then coincides with a ready decrease in the lift-curve slope and the approach to the actual lift-curve peak. The rapid yet gradual spanwise spread of the separated area, simultaneously, prevents the formation of a deep local stall in a chordwise or vertical sense at any section; steep spanwise pressure gradients and hence spanwise cross flow are thereby effectively prevented.

The inboard expansion of the stalled area, aside from producing the desired stall warning, will reduce the downwash at the tail; the increased static longitudinal stability and lowered trim CL provide the nose-down pitching moment which is required for prompt recovery after the stall.

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Stall Characteristics of Wings with Three Controlled Sections ("tri-section wing")

The subject method is based on the use of three controlled sections, at the wing root, another at a mid-span station, and the third at the wing tip, with straight lines connecting the corresponding coordinates.

Defendants' Exhibit D—(Continued)

By judicious selection of the camber and thickness ratios of the three controlled sections it becomes possible to obtain spanwise distributions of maximum section lift coefficients similar to that shown in Figure 7. A comparison of the spanwise distributions of actual and maximum attainable section lift coefficients discloses that the previously postulated requirement of a midspan stall progressing evenly inboard and outboard is met.

A convenient procedure for the selection of the most appropriate parameters (camber and thickness ratio) for the three controlled sections is based on the fundamental information of the variation of maximum lift and zero-lift angle with camber, thickness ratio, and Reynolds number for a given airfoil, required for the respectively selected airfoil family.

A preliminary selection of the three controlled airfoil sections is undertaken, mainly on the basis of past experience. The camber and thickness ratios of several intermediate stations are then determined and the variation of CL max. vs. Reynolds number is plotted for these representative airfoil sections (Fig. 8). Assuming the approximate airspeed at which the stall is expected, the Reynolds numbers of the various spanwise stations are computed and plotted on the CL max. vs. Reynolds Number graph.

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The resulting curve of maximum lift coefficients is then transferred to the graph of CL max. versus span. If the resulting relation between the CL

Defendants' Exhibit D—(Continued)

max. available curve and the spanload distribution is not satisfactory, minor adjustments of the camber, thickness ratios, and the washout will modify the two spanwise distributions until the desired result is obtained.

The variation between maximum lift coefficients and thickness ratio shows a certain peculiarity which can be employed to good advantage. Most airfoil families reach their absolutely highest CL max. at a thickness ratio between 12 and 16 per cent. Thickness ratios greater or lesser than the optimum value result in lower maximum lift coefficients. Consequently, if a thickness lesser than optimum is used for the wing tip, where the load is greatly reduced from its peak value, the optimum airfoil thickness can be located at the spanwise station a small distance inboard of the wing tip where the highest load is reached (Fig. 9).

Wind Tunnel Testing for Stalling Characteristics

Wind-tunnel testing on small-scale models for the prediction of the full-scale stalling characteristics is generally not entirely satisfactory because it is extremely difficult to reproduce the full-scale Reynolds number without exceeding the full-scale Mach number. This is particularly disconcerting when testing in small, atmospheric tunnels during the preliminary-design stage of a new-type aircraft, at which phase accurate data for the estimation of the full-scale stalling characteristics are most urgently required.

Defendants' Exhibit D—(Continued)

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Some assistance, at least, on this perplexing problem can be gained from the CL max. vs. Reynolds Number graph, where model Reynolds numbers are used instead of full-scale values.

No general rule on the comparative character of the stalling characteristics at model and full-scale can be advanced but it is recommended that a prediction of the model stalling characteristics be made prior to the wind-tunnel test not only to test the accuracy of the method, but also to uncover the existence of any unforseen interference factors on the stall characteristics.

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Conclusion

The adoption of a third controlled airfoil section near mid-span permits the attainment of any desired stall characteristics by eliminating the localized deep stalls over the outboard panels.

A desirable apportionment of spanwise lift distribution at relatively high lifts and Mach numbers can be determined for given stall characteristics, because a satisfactory stall can be obtained with a smaller spanwise variation of camber.

The method has been successfully tested on wings with taper ratios up to 4:1 and leading edge sweepbacks up to 15°. Because of military restrictions the visual demonstration of stall characteristics on a wind-tunnel model must be limited to photographs of a non-confidential research wing with taper ratio 3:1 which is, however, fully representative of wings

Defendants' Exhibit D—(Continued)

with higher taper ratios and greater sweepback. The airfoils used are NACA 2518, 3515 and 4512, respectively (Ref. 2). No aerodynamic washout is incorporated. A theoretical comparison of the stalling characteristics of this wing and a wing with straight line fairing between a 2518 root airfoil and a 4512 tip airfoil (no aerodynamic washout) is shown in Figure 10. It is of significance that the stall of the "tri-section wing" begins at a wing lift coefficient of 1.5 against a stalling lift coefficient of 1.4 in a conventional straight-line faired two-section wing. Photographs 1 to 5 substantiate the concurrence of estimated and experimentally obtained characteristics of the "tri-section wing."

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References

1. Determination of the Characteristics of Tapered Wings by Raymond F. Anderson NACA Technical Report No. 572, 1933.

2. The Characteristics of 78 Related Airfoil Sections from Tests in the Variable—Density Wind-Tunnel by Eastman N. Jacobs,
   Kenneth E. Ward, and
   Robert W. Pinkerton
   NACA Technical Report No. 460, November, 1933.

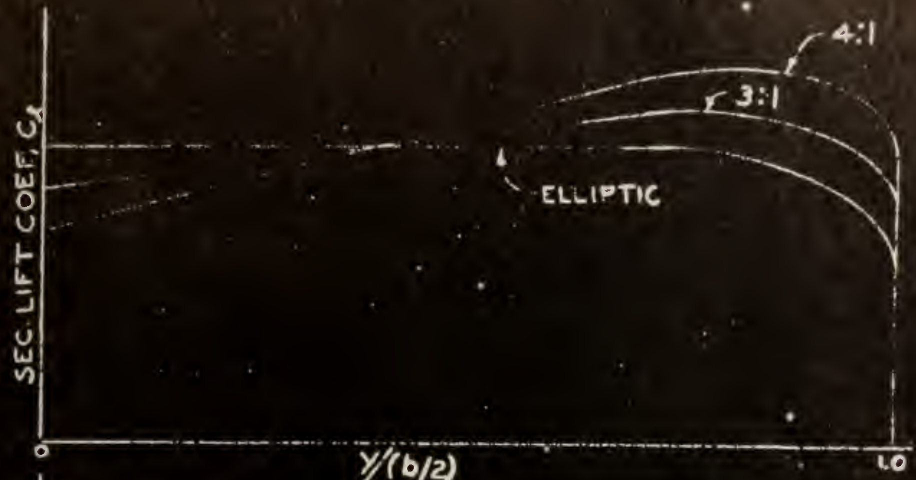

FIG. 1

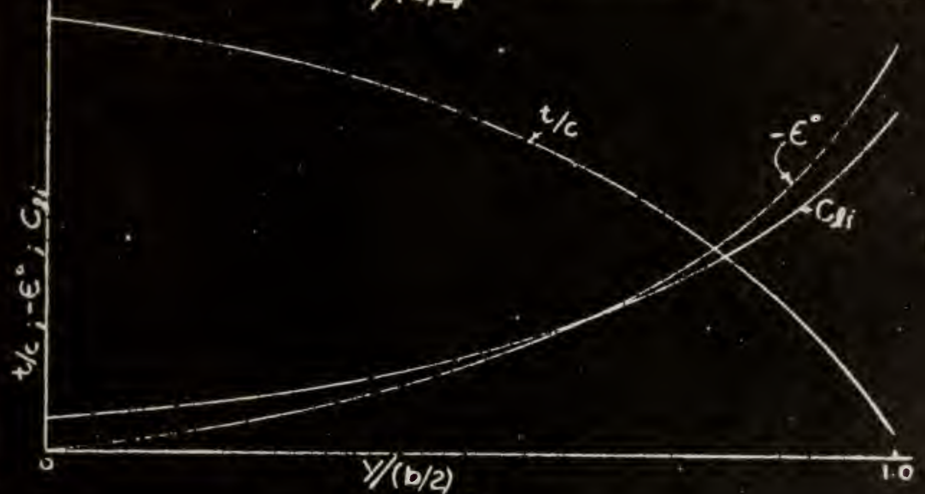

FIG. 2

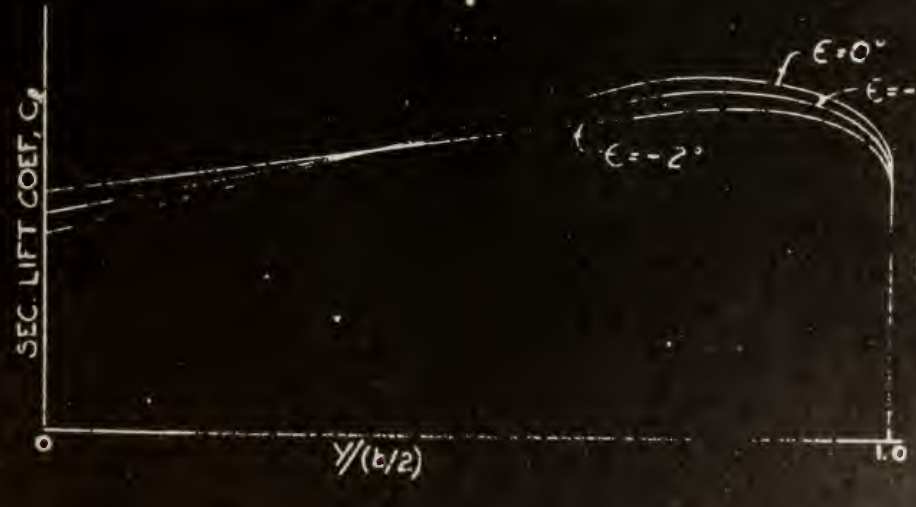

FIG. 3

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SAN DIEGO CALIFORNIA

MODEL AIRPLANE REPORT NO.

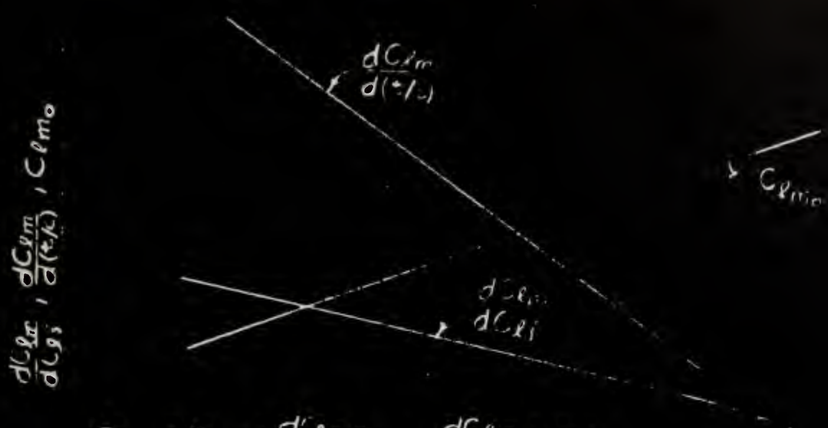


FIG. 4

$$C_{l_{max}} = C_{l_{mo}} + \frac{dC_{l_m}}{dC_{l_i}} C_{l_i} - \frac{dC_{l_m}}{d(t/c)} \Delta(t/c)$$

LOW REYNOLDS NUMBER

FIG. 5

FIG. 6

BY
CHECKED
APPROVED

MODEL AIRPLANE REPORT NO

FIG. 7

FIG 8

FIG. 9

BY__________

CHECKED__________

APPROVED__________ 15V

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SAN DIEGO, CALIFORNIA

MODEL AIRPLANE REPORT NO

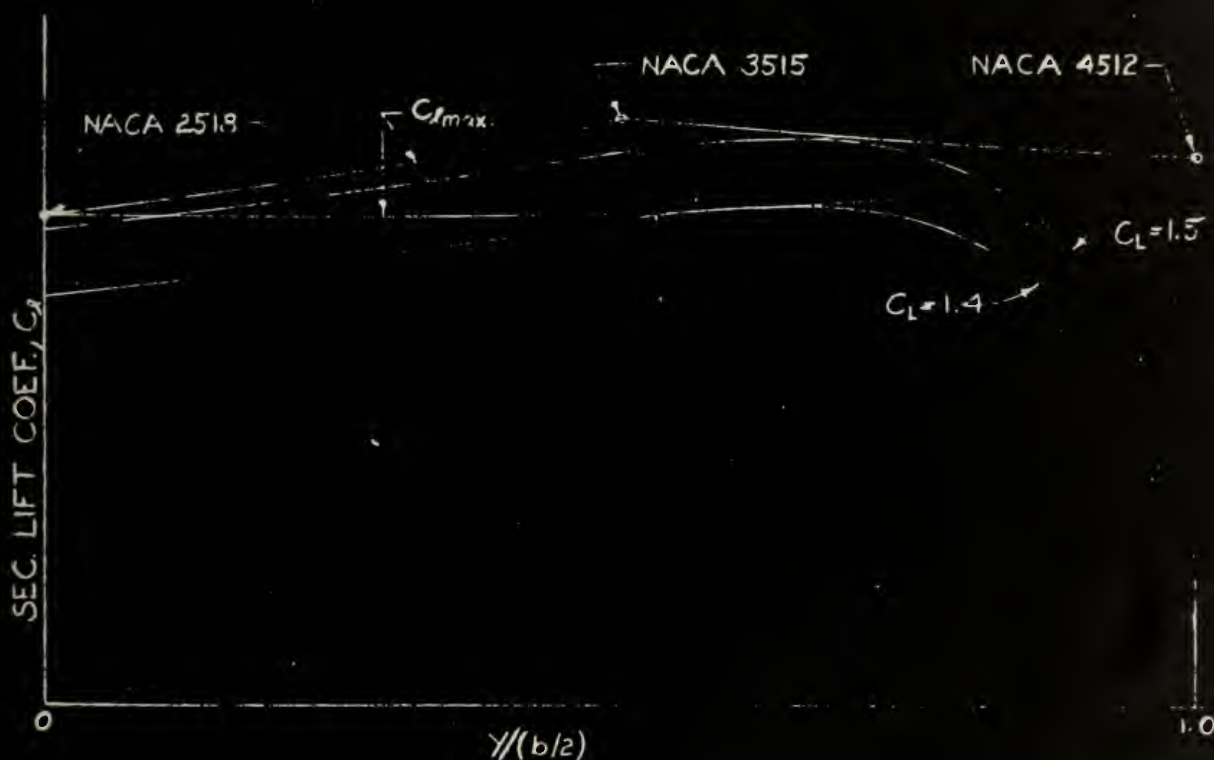


FIG. 10

Admitted November [illegible], 1950.

BY
CHECKED
APPROVED

DEFENDANTS' EXHIBIT E

Consolidated Vultee Aircraft Corporation
General Offices, San Diego, California

19 December, 1944

Mr. D. A. Hall
Mr. M. A. Garbell

Disclosure of Method of Effective Control of Stalling Characteristics of Highly Tapered and Swept-Back Wings.

Enclosed is a copy of my paper on "Effective Control of Stalling Characteristics of Highly Tapered and Swept-Back Wings" for your information and file.

Please consider this paper an official disclosure of invention. I shall be glad to complete the disclosure with any additional material that may be requested by you.

M. A. GARBELL.

[Stamped]: Patent Dept., Dec. 20, 1944. Consolidated Vultee Aircraft Corporation.
MAG:lm

Admitted November 22, 1950.

DEFENDANTS' EXHIBIT F

Consolidated Vultee Aircraft Corporation
San Diego Division, San Diego, California

January 8, 1945

Dr. Maurice A. Garbell
R. Evers

Your Disclosure on Stall Characteristics on Variable Section Wings

(a) D. A. Hall verbal request Jan. 1, 1945

It has been brought to our attention that some additional information would be desirable to further clarify your subject disclosure.

Mr. D. A. Hall has requested that, if available, the following data be sent to him:

(a) Curve showing reduction of drag coefficient (Cd) by your method over the conventional design.

(b) A tabulation of symbols used in the disclosure.

(c) Copies of N.A.C.A. references.

Mr. Hall should also be advised if you have received the information you requested from Vultee Field.

R. EVERS.

RE:mh
cc: R. Evers
Dev. Engr. File

Admitted November 24, 1950.

DEFENDANTS' EXHIBIT G

District Court of the United States, Southern District of California, Central Division

Civil Action No. 10930-Y

MAURICE A. GARBELL, INC., a California Corporation, and GARBELL RESEARCH FOUNDATION, a California Corporation,

Plaintiffs,

vs.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION, a Delaware Corporation, and AMERICAN AIR LINES, INC., a Delaware Corporation,

Defendants.

STIPULATION #11

It is hereby stipulated subject to proof of error that the appended "Exhibit 125" is a reproduction of pages 8 and 9 of Volume 8 of a printed publication "L'Aquilone" containing an article entitled "Tre nuovi veleggiatori italiani per il 1938" published and issued by Editorial Aeronautica in Rome, Italy, in the year 1938, and that "Exhibit 125a" is a translation of said article (subject to correction if any error is contained therein), and that said "Exhibit 125" may be used in evidence with the same force and effect as an original, subject to any

Defendants' Exhibit G—(Continued)

objection which may be made thereto as irrelevant or immaterial when offered in evidence, viz.;

LYON & LYON,
/s/ FREDERICK W. LYON,
Attorneys for Plaintiffs.

/s/ ROBERT B. WATTS,
/s/ FRED GERLACH,
Attorneys for Defendants.

Exhibit 125a

From L'Aquilone, Jan. 16, 1938, pp. 8 & 9

Translation from: Italian WB:GS

Three New Italian Soaring Gliders for 1938

The great advance which has recently been experienced by Italian gliding in the 15th Year of the Fascist Regime, as a result of the interest shown by the executives of the R.U.N.A., has placed the problem of soaring gliders on the agenda. In Asiago, we saw Italian planes which had been constructed or else designed at least 3 to 4 years ago, as well as the German soaring gliders brought from Cattaneo, namely the "Condor I" and the "Hutter" 17, which no longer represent the last word in the construction of gliders.

This situation was well understood by the Gliding Research and Experimental Center of the Royal Polytechnicum and the G.U.F. of Milan and also by the Societa Aeronautica Lombarda which, as is well-known, has up to now supplied almost all the

Defendants' Exhibit G—(Continued)

gliders to the motor-less flight schools of the Party. Between the two organizations, the one of a scientific technical nature and the other of a manufacturing nature, a fruitful agreement has been entered into in accordance with which the S.A.L. will greatly assist the Center in the construction of its two models, while the latter agreed to grant licenses for mass production.

In accordance with this agreement, which shows a characteristically Fascistic spirit of cooperation, and for the purpose of finally giving Italy the models which the ability of the Italian pilots merits, there were rapidly brought out the three models which were to represent the three classical categories of the high-gliding school, namely the performance-type glider, the secondary-type glider and the primary-type glider. There should be mentioned the extremely short time of construction: The "Pinguino GP. 1," a high-class soaring glider, was designed and constructed in 150 work days (during the Asiago rally, the work was interrupted due to the absence of the designers); the "Alcione BS 28" and the "Asiago GP 2" were both born in 100 days, counting from the first rough sketch to the flight test.

"L'Aquilone" has already related ("The Birth of the Pinguino" and "At the Salon") the story of the construction of the Pinguino and of the "Asiago" and there will now be described briefly (as we ourselves have seen it) the testing of the 3 planes. We now have a clear idea as to how these

Defendants' Exhibit G—(Continued)

3 planes are made, how they were born and how they will be used.

Let us follow the chronological order of the creation of the 3 planes; first of all, the "Pinguino GP 1," which did not see the light of day in the subterranean darkness of the Milan Polytechnicum.

The "Pinguino G. P. 1"

The external lines of the "Pinguino" are those characteristic of M central wing soaring gliders ("Rhonsperber," "Tulak," etc.). The main technical specifications are:

Wing span	13.30	meters
Length	6.50	"
Wing surface	15.20	m2
Aspect ratio	15	
Deadweight	170	kgs.
Useful load	80	"
Total weight	250	"
Wing loading	15.2	kg/m2
Coefficient of strength	9	
Minimum velocity of descent in m/sec.	0.69	
Gliding angle	1:25.3	

The wing is completely of the cantilever type. The plan of the wing is rectilinear in the central portion and tapers towards the tip. In the central portion, the dihedral of which is 6°, there has been used the Gottinga G 535 profile which is constant up to the bend. At the tip, however, the N.A.C.A. 23012 profile is used. The course of the profile in

Defendants' Exhibit G—(Continued)

the tapered part of the wing is gradual and linear. The geometrical warping (i.e., of the reference chords) of the two airfoils is 0, but in view of the difference between the conventional reference chords in the Gottinga and N.A.C.A. systems, the aerodynamic warping attains a value of about 3°. In the first three ribs at the root of the wing, the G. 535 profile is not, however, maintained constant, but passes with a parabolic course into an ideal N.A.C.A. 0015 profile which, as is well known, is symmetrical. The connection between wing and fuselage is effected almost automatically, which greatly improves the lift distribution on the wing in the vicinity of the fuselage.

The wing is of the monospar type, with a small false rear spar. The main spar is of the box type, consisting of upper and lower cap-strips connected with each other by means of the two plywood side walls. The cap-strips are of spruce plywood, that is to say they consist of many strips of a height of about 1 cm. which are glued together. In this manner, the spar is not only much stronger than a spar made of a single piece, but it is also possible to construct the spar without connection to the bend of the M since the use of glued plywood does away with the internal stresses coming from the bending of the individual strips.

The leading edge contributes greatly to the resistance, withstanding practically all the torsional forces. It is therefore covered with birch plywood of a thickness of 10/10, 15/10 and 20/10 mm. Need-

Defendants' Exhibit G—(Continued)

less to say, all the plywood used is first-quality wood, approved by the G.A. In order to maintain the form of the torque tube which is the leading edge, false ribs are interspersed between the ribs, the 30 cm. distance between which appeared excessive for this purpose. All of the ribs are of domestic poplar of first-class quality, having normal panelwork and reinforced with plywood gussets of a thickness of 10/10.

The aileron is of a single piece controlled by two levers, but at the present time it has been divided into two parts of differential action in order further to increase the efficiency. The transverse control has a differential of about 1:2.5 and therefore one aileron rises about 2.5 times more than the other is lowered. As a matter of fact, it is known that in order to obtain equal values of increase or decrease of lift, the aileron must have a greater travel upward than downward. Furthermore, an excessive lowering of the aileron is harmful in that the lowering, in addition to increasing the lift of the wing, also increases the resistance to forward motion. If, for example, we give "contrary ailerons" while banking, for the purpose of straightening the ailerons, there takes place a braking of the inner wing and therefore an action which tends to maintain the plane in the bank. This entire reasoning has brought about the idea of applying differential control to the ailerons.

The transmission of the torsional forces from the leading edge to the fuselage occurs along the diag-

Defendants' Exhibit G—(Continued)

onal which transmits them to the rear connection of the wing to the fuselage. The metal connections are of carbon and chrome molybdenum steel and the pins are of chrome molybdenum steel.

It is already known that on each pin there acts about 19,200 kgs. compression or tension, which justifies the use of steel of the highest strength.

On the upper surface of the wing, there is located a CVV type flap of 600 sq. cm. surface. The purpose of this flap is to increase the velocity of descent from 0.70 to about 2 meters per second and to change the gliding angle to about 1:10. The flap consists of a duraluminum plate set normally to the upper surface of the wing. By means of a simple mechanism consisting of a few curved levers, a cable and 7 rollers, the movement of the flaps is controlled by a lever located beneath the instrument board. It suffices for the pilot to pull this lever in order to elevate the two flaps. Two torsion springs return the flaps into the rest position as soon as the pulling on the lever ceases. The CVV flaps have proven extremely efficient right from the first flight. The progress realized, as compared with the old Jacobs flaps which adhered to the wing along an edge, is remarkable. The disturbing effect is considerably greater but at the same time more regular. In no case was there noticed any vibration or shaking of the tail, which is so troublesome in other gliders. The efficiency of the CVV flap is of course not as great as that of the double split flaps of the Jacobs type, which however cost much more on

Defendants' Exhibit G—(Continued)

account of the greater mechanical complication. In any event, the results obtained up to the present time are very encouraging.

The fuselage is of ovoid section generated by circular arcs. While in the rear part of the fuselage, there are three circular arcs, leaving one sharp edge below; in the rear part, the shape consists of four connected arcs. With a somewhat simpler design, there is thus obtained an excellent section. The sharp angle keel which is present in the rear part of the fuselage has an important stabilizing action, especially during sustained flight. As a matter of fact, it retards and hampers the side slip.

The fuselage consists of six spars and twenty frames. However, the main purpose of these members is to maintain the shape of the fuselage intact inasmuch as the resisting member is constituted by the plywood covering. We thus have a monocoque structure.

The elevator consists of a fixed plane entirely of the cantilever type connected to the fuselage by means of four bolts and a movable unbalanced plane. The control of the latter is effected by means of a lever on the inside. Not even the rudder is aerodynamically compensated.

The cockpit is very commodious. The adjustable seat perfectly fits the shape of the human body. The pedals consist of two wooden pedals hinged at the bottom. The cowling is completely transparent and offers optimum visibility in all directions, even rearward.

Defendants' Exhibit G—(Continued)

A normal ash skid covered with a thin strip of sheet steel and made resilient by rubber absorbers, absords the landing shocks. The tail skid consists of a strip of duraluminum sheet metal below the rear nose.

In the next issue, we shall publish the description of one of the other two soaring gliders.

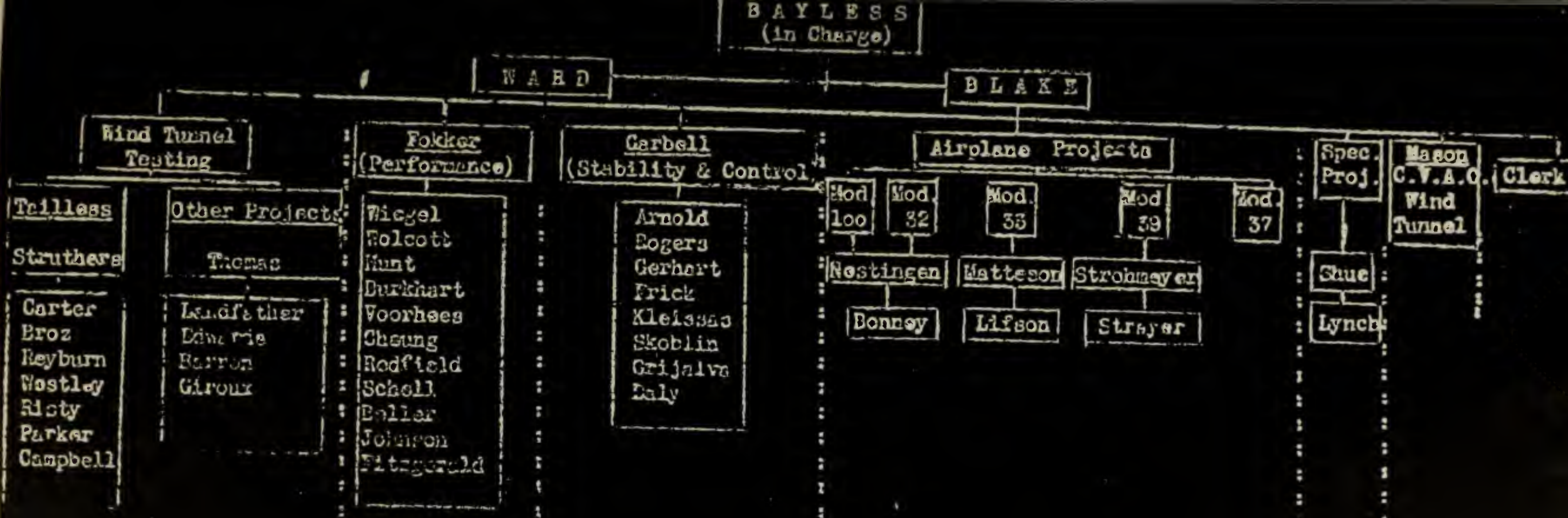
Translation of Captions

(A) These three photographs show the "Pinguino" just after assembly, top view; in the center there is shown the statical testing of the wing, and at the bottom there is shown the glider in flight.

(B) A view of the frame of the fuselage of the "Pinguino" during construction.

(C) The frame of the right half-wing of the "Pinguino."

Admitted November 22, 1950.



April 6, 1944.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
LINDBERGH FIELD - SAN DIEGO, CALIFORNIA.

Defts Ex 117
HHart

Admitted November 22, 1950.

166

DEFENDANTS' EXHIBIT I

LINDBERGH FIELD . SAN DIEGO, CALIFORNIA /C+Le

April 4, 1944.

RESPONSIBILITY

important decisions with respect to aerodynamic design, selection engines, propellers, etc; all performance, wind tunnel test programs, d tunnel models; and all changes to airplanes under flight test shall approved in writing by the Engineer in Charge except that Mr. Ward, ing as an Assistant to the Engineer in Charge, shall approve the work e by the Airplane Projects and Special Projects personnel and Mr. ke, acting as an Assistant to the Engineer in Charge, shall approve work done by the Wind Tunnel personnel.

d Tunnel Testing -
Wind tunnel models.
Wind tunnel tests.

formance -
All performance
FOR NEW DESIGNS
(a) Wing Area
(b) Aspect Ratio
(c) Tail Area
(d) Fuse. Shape
(e) Nac. Shape
(f) Turret Inst.
(g) Protuberance Des.
(h) Surface Cond.
(i) Leakage
(j) Misc. Char. Affecting Drag
(k) Engine Selection and Establishment of BHP, SFC, etc.
(l) Prop. Selection and Eng. Gear Ratio
(m) Turbo Selection
(n) Flap Selection
(o) Landing Gear Tread Wheelbase and Ground Angle
(p) Satisfactory Attitude of Fuselage for Various Flight Conditions

For EXISTING DES.
All Characteristics Affecting Drag and Performance
Satis. Eng. Cooling New and Existing Designs

Clerk -
(a) All scheduled records and status reports
(b) Time record
(c) Files

Stability and Control -
(1) Satisfactory stability, control and flying characteristics in flight and in wind tunnel tests
(2) Wind tunnel reports, test programs and test predictions
(3) Aero. data for structural analysis
(4) FOR NEW DESIGNS
(a) Airfoils
(b) Wing, tail and control surface, geometry and design
(c) Wing and tail incid.
(d) Tail Length
(e) Flap design
(f) C.G. limits for adequate stability and control

Airplane Projects -
(1) All specific flight predictions
(2) Flight test programs
(3) Flight prediction and characteristics summary report (60 days prior initial flight of new design)
(4) Engineering and Shop Liaison to assure that all aerodynamic characteristics are maintained as planned.

Special Projects -
(1) Prediction of compressibility effects

CVAC Wind Tunnel -
(1) Expedite and coordinate CVAC Wind Tunnel Project

H. H. Hart

161

DEFENDANTS' EXHIBIT J

CONSOLIDATED AIRCRAFT CORPORATION — San Diego, California

Employment Division

Industrial Relations Department

ASSIGNMENT TO EMPLOYMENT

ame........ Sex .... Clock No. 6-1801

Shift

partment........ Rate 1 .... 2 .... 3 ....

assification........ A .... Code 67531

arting Date........ Hour ....

marks:

Hired by........ Date........

m 609

EXH 111

CONSOLIDATED VULTEE AIRCRAFT CORPORATION SAN DIEGO, CALIF.

CHANGE IN EMPLOYEE'S STATUS

NAME Garbell, M. A. EFFECTIVE DATE 8-21-43 TIME A.M. P.M.

	FROM	TO
DEPARTMENT	Dev. Eng.	
CLOCK NUMBER	1-61-1082	
RATE & SHIFT	(175. SM) 162.40 BW	162.40 BW

JOB TITLE GRADE AND CODE NUMBER — FROM Aero. Engineer A 7531 — TO same

REASON: Order #35

RATE CHANGE ☐ JOB TITLE CHANGE ☐ SHIFT CHANGE ☐ INTER-DEPT. TRANSFER ☐ RECORD CORRECTION ☐

SIGNED C A Phillips DEPARTMENT FROM — SIGNED DEPARTMENT TO

WAGE REVIEW	MANAGEMENT	ACCOUNTING
APPROVED	APPROVED Ree	ADD
APPROVED	APPROVED R M Andrews	TAB AUG 21 43
		PAYROLL

FORM 1039A

ACCOUNTING DEPT. COPY

EXH 112

CONSOLIDATED VULTEE AIRCRAFT CORPORATION — SAN DIEGO DIVISION

CHANGE IN EMPLOYEE'S STATUS

FSP

NAME: M. A. Garbell — EFFECTIVE DATE: 5-1-44 — TIME: A.M. / P.M.

	FROM	TO
DEPARTMENT	Dev. Engr.	Same
CLOCK NUMBER	661-1-379745 F	Same
RATE & SHIFT	247.50 SM FSP 1st	267.50 SM FSP 1st

JOB TITLE GRADE AND CODE NUMBER: FROM Group Engineer 1160; TO Same

REASON: Six Months Review

MALE	FEMALE	FULL TIME	PART TIME	ADULT	MINOR

RATE CHANGE [X] — JOB TITLE CHANGE [ ] — SHIFT CHANGE [ ] — INTER-DEPT. TRANSFER [ ] — RECORD CORRECTION [ ]

SIGNED ____ DEPARTMENT FROM — SIGNED ____ DEPARTMENT TO

WAGE REVIEW — APPROVED ____ — APPROVED ____

MANAGEMENT — APPROVED ____ — APPROVED ____

ACCOUNTING — ADD ____ — TAB ____ — PAYROLL ____

FORM [illegible]

ACCOUNTING DEPT. COPY

EXH 118

CONSOLIDATED VULTEE AIRCRAFT CORPORATION — SAN DIEGO DIVISION

1868 CHANGE IN EMPLOYEE'S STATUS

FSP

NAME: Garbell, M. A. — EMPLOYEE NUMBER: 379745 — PAYROLL: FSP

DATE ISSUED: 12-21-44 — TIME: A.M. / P.M. — DATE EFFECTIVE: 2-1-45 [illegible] — TIME: A.M. / P.M.

	FROM	Retro 1-1-45 TO
DEPARTMENT	Dev. Engr. 661-1-	Same
RATE & SHIFT	(267.50)267.50SM FSP1st	(285.)285. SM FSP 1st

JOB TITLE GRADE AND CODE NUMBER: FROM Group Engineer 1160; TO Design Specialist A 2633

REASON: Adj. toward minimum
P&AConv. [illegible]

MALE	FEMALE	FULL TIME	PART TIME	ADULT	MINOR
X		X		X	

RATE CHANGE [X] — JOB TITLE CHANGE [ ] — [ ] — INTER-DEPT. TRANSFER [ ] — RECORD CORRECTION [ ]

SIGNED ____ DEPARTMENT FROM — SIGNED ____ DEPARTMENT TO

WAGE REVIEW — APPROVED ____ — APPROVED ____

MANAGEMENT — APPROVED ____ — APPROVED ____

ACCOUNTING — ADD ____ — TAB ____ — PAYROLL ____

FORM 1028C

ACCOUNTING DEPT. COPY

[illegible]

FSP COP

CONSOLIDATED VULTEE AIRCRAFT CORPORATION SAN DIEGO, CALIF.

CHANGE IN EMPLOYEE'S STATUS

NAME Garbell, Maurice A EFFECTIVE DATE 11-1-43 TIME TO A M P M

	FROM	TO
DEPARTMENT	Dev. Engr. 1-61	Same
CLOCK NUMBER	1-61-1082	1-61-155
RATE & SHIFT	162.40 BW	247.50 SM FSP

JOB TITLE GRADE AND CODE NUMBER FROM Aero. Engineer "A" 7531
TO Design Engineer 7610

REASON: Merit Increase NO RED BADGE

RATE CHANGE [X] JOB TITLE CHANGE [X] SHIFT CHANGE [ ] INTER-DEPT. TRANSFER [ ] RECORD CORRECTION [ ]

SIGNED C. A. Phillips DEPARTMENT FROM SIGNED DEPARTMENT TO

WAGE REVIEW APPROVED APPROVED | MANAGEMENT APPROVED APPROVED R. M. Andrews | ACCOUNTING OCT 30 '43 ADD ADD TAB TAB. NOV 02 '43 PAYROLL

FORM 1039A

ACCOUNTING DEPT. COPY

EX - 114

CONSOLIDATED VULTEE AIRCRAFT CORPORATION SAN DIEGO DIVISION

CHANGE IN EMPLOYEE'S STATUS

FSP

NAME Garbell, M.A. EFFECTIVE DATE 3-16-44

	FROM	TO
DEPARTMENT	Dev. Engr.	Same
CLOCK NUMBER	661-379745 F	Same
RATE & SHIFT	FSP 1st	Same

JOB TITLE GRADE AND CODE NUMBER FROM Aerody. Engr. A 2533
TO Group Engineer 1160

MALE | FEMALE | FULL TIME | PART TIME | ADULT | MINOR

REASON: S.S.U. Conv.

RATE CHANGE [ ] JOB TITLE CHANGE [X] SHIFT CHANGE [ ] INTER-DEPT. TRANSFER [ ] RECORD CORRECTION [ ]

SIGNED C A Phillips DEPARTMENT FROM SIGNED DEPARTMENT TO

WAGE REVIEW APPROVED ✓ APPROVED | MANAGEMENT APPROVED APPROVED R. M. Andrews | ACCOUNTING MAR 14 '44 ADD TAB PAYROLL P R

FORM 1039A

ACCOUNTING DEPT. COPY

EXH 115

Admitted November 22, 1950.

DEFENDANTS' EXHIBIT K

Contract No. W 535 ac-24664
(6731)

Contract
(Supplies)

MW:RH

ANMB Preference AA-1 & A-1-A
Allocation Classification System Symbols: USA-1.00

War Department
(Department)

Vultee Aircraft, Inc.
(Contractor)

Contract for 400 A-35B Airplanes, Static Test Airplane, Spare Parts and Data. Amount, $34,-034,840.00.

Place: Army Air Forces, Materiel Center, Wright Field, Dayton, Ohio.

The Finance Officer, U. S. Army, Wright Field, Dayton, Ohio, is designated as the officer to make payments in accordance with this contract. The supplies and services to be obtained by this instrument are authorized by, are for the purpose set forth in, and are chargeable to the Procurement Authorities listed hereon, the available balances of which are sufficient to cover the cost of the same.

AC 2312
P 12-09
A 0705-23 ....$24,339,000.00 Class. 01-A
AC 2382
P 82-09
A 0705-23 .... 9,695,840.00 01-Q
$34,034,840.00 AAF Stock No. 0103

Defendants' Exhibit K—(Continued)

AFP: 194465

This contract supersedes Letter Contract Special Form dated January 16, 1942.

Approval recommended: September 22, 1942.

/s/ O. P. ECHOLS,
Major Gen., U.S.A., Commanding General, Materiel Command.

Approved: Sep. 22, 1942.

By direction of the Secretary of War, under the provisions of the First War Powers Act, 1941, and Executive Order No. 9001, December 27, 1941.

/s/ PHILLIPS W. SMITH,
Col., A.U.S., Special Representative of the Under Secretary of War.

Article 51

Approval.—This contract shall be subject to the written approval of the Secretary of War or such individual as said Secretary may designate and shall not be binding until so approved. The date of such approval shall be deemed to be the true date for the purpose of determining all times of performance.

Article 52

Alterations.—The following changes were made in this contract before it was signed by the parties hereto: Articles 15, 15A, 16, 16A, 17 to 52, inclusive, on pages 4a, 4a-1, 4a-2, 4a-3, 4a-4, 4a-5, 4b to 4n, 4n-1, 4n-2, 4n-3, 4n-4, 4n-5, 4o to 4s, inclusive, added, all as approved by the Director of the Bureau of

Defendants' Exhibit K—(Continued)

the Budget and/or the Under Secretary of War. The letter "(a)" inserted after the heading "Taxes" in the first line of Article 29 and paragraph (b) added thereto.

In Witness Whereof, the parties hereto have executed this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA

By /s/ JOSEPH E. DERHAM,
Lt. Colonel, Air Corps, Contracting Officer, U. S. Army.

VULTEE AIRCRAFT, INC.,
Contractor,

By /s/ V. C. SCHORLEMMER,
Vice-Pres.,
Downey, California.
(Business address)

Two witnesses:

/s/ GLORIA WEAVER,
/s/ BETTY BROTHER.

I, T. C. Sullivan, certify that I am the Secretary of the corporation named as contractor herein; that V. C. Schorlemmer, who signed this contract on behalf of the contractor, was then Vice President of said corporation; that said contract was duly signed for and in behalf of said corporation by

Defendants' Exhibit K—(Continued)

authority of its governing body, and is within the scope of its corporate powers.

[Corporate Seal]

/s/ T. C. SULLIVAN.

I hereby certify that, to the best of my knowledge and belief, based upon observation and inquiry, ..., who signed this contract for the ...., had authority to execute the same, and is the individual who signs similar contracts on behalf of this corporation with the public generally.

........................,
Contracting Officer.

W 535 ac-24664

Defendants' Exhibit K—(Continued)

Supplemental Agreement No. 1
to
Contract W 535 ac-24664

Contractor: Vultee Aircraft, Inc.
Vultee Field, California

X

X

X

X

X

Approval Recommended: December 15, 1942.

/s/ O. P. ECHOLS,
Major Gen., U.S.A., Commanding General Materiel Command.

Approved: Dec. 17, 1942.

By direction of the Secretary of War, under the provisions of the First War Powers Act, 1941, and Executive Order No. 9001, dated December 27, 1942.

/s/ PHILLIPS W. SMITH,
Lt. Col., Ord. Dept.

ALBERT J. BROWNING,
Colonel, General Staff Corps, Special Representative of the Under Secretary of War.

Defendants' Exhibit K—(Continued)

In Witness Whereof, the parties hereto have executed this Supplemental Agreement No. 1 as of the day and year first above written.

THE UNITED STATES OF AMERICA,

By /s/ JAMES W. SHOCKNESSY,
Capt., A.C.,
Contracting Officer,

WM. MITCHELL,
Captain, Air Corps, U. S.
Army, Contracting Officer.
(Official Title)

VULTEE AIRCRAFT, INC.,
(Contractor)

By /s/ DAVID G. FLEET,
Executive Vice-President,
Vultee Field, California.
(Business Address)

Two Witnesses:

/s/ E. LAESAKU,

/s/ C. W. CROCKER.

I, O. R. Stocke, certify that I am the Assistant Secretary of the corporation named as Contractor herein; that David G. Fleet, who signed this Supplemental Agreement on behalf of the Contractor, was then Executive Vice-President of said corporation; that said Supplemental Agreement was duly signed for and in behalf of said corporation by

Defendants' Exhibit K—(Continued)

authority of its governing body, and is within the scope of its corporate powers.

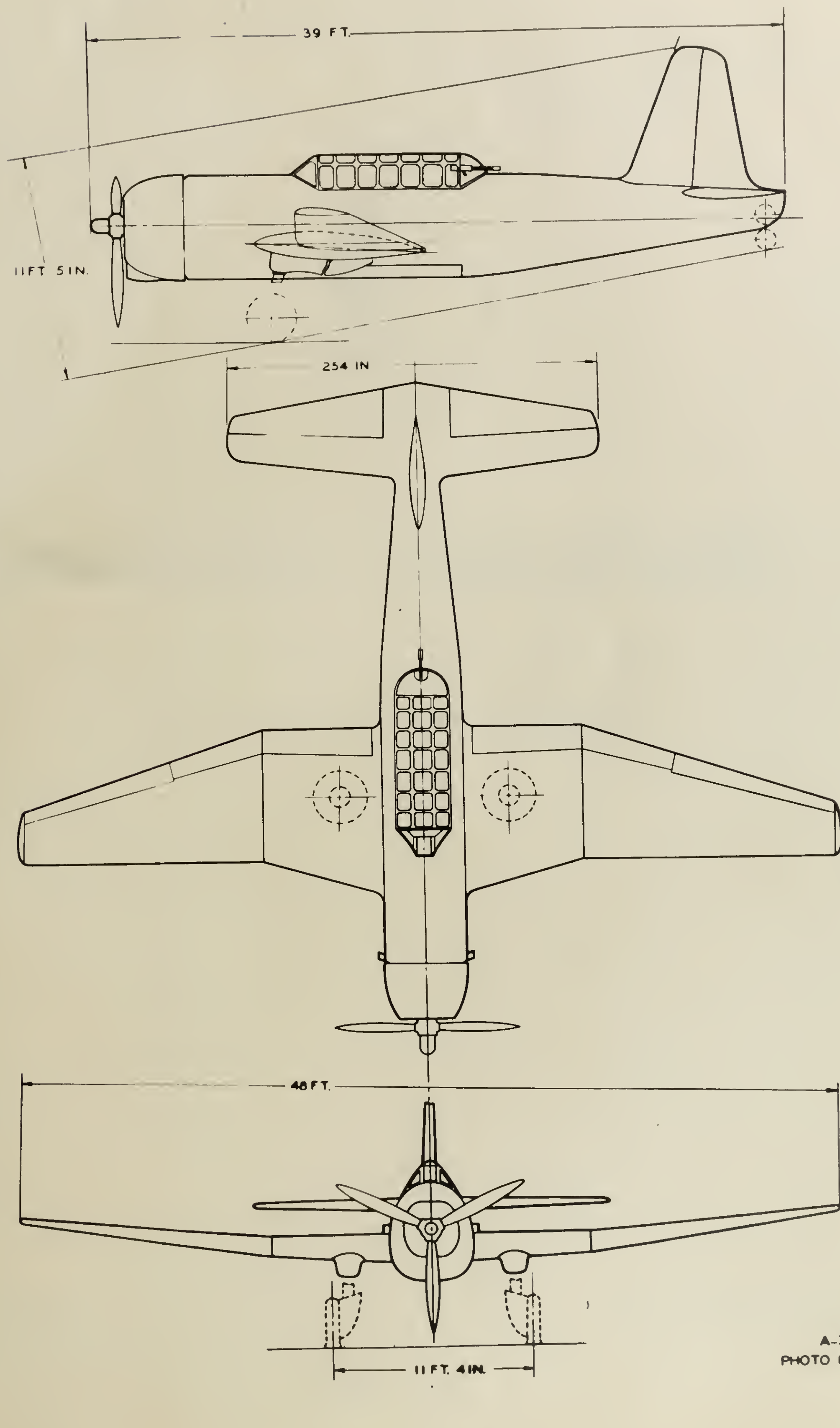
[Corporate Seal]

C. R. STOCKE.

I hereby certify that, to the best of my knowledge and belief, based upon observation and inquiry, ..., who signed this Supplemental Agreement for Vultee Aircraft, Inc., had authority to execute the same, and is the individual who signs similar contracts on behalf of this corporation with the public generally.

........................,
(Contracting Officer)

Page 8 of Supplemental Agreement No. 1 to Contract No. W 535 ac-24664.



A-35B-VN
PHOTO NO. 14581

FOR OFFICIAL USE ONLY

AIR PUBLICATION 2024A
VOLUME I

VENGEANCE I AEROPLANE

WRIGHT GR-2600-A5B-5 ENGINE

AIR MINISTRY

B.A.C./3.42/VULTEE

JUNE 1942

FRONTISPIECE

Defendants' Exhibit K—(Continued)

Air Publication 2024A
Vol. I

Leading Particulars

Type	Two-seater, single engined, low wing, land monoplane
Duty	Day and night dive bombing

Principal Dimensions

(Airplane in flying attitude unless otherwise stated)

Span	48 ft. 0 in.
Length (Overall)	40 ft. 0 in.
Height (Over radio mast)	12 ft. 0.69 in.
Length (Tail wheel on ground)	39 ft. 4.3 in.
Height (Over propeller tip, tail wheel on ground)	14 ft. 6 in.

Wing

Airfoil Section:	
At Wing Root	NACA 14516-64
At Outer Panel Joint	NACA 14516-64
At Tip	NACA 20509-64
Chord at Fuselage Centerline	10 ft. 6 in.
Chord at Outer Panel Joint	7 ft. 6 in.
Chord at Tip	3 ft. 6 in.
Incidence	0°
Dihedral measured on chord plane of Inner Panel	1° 33′36″
Dihedral measured on chord plane of Outer Panel	7°
Sweepback at leading edge of Inner Panel	16° 10′52″
Sweepback at leading edge of Outer Panel	0°

11

Vultee

MODEL 72

REPORT 1793 Part I
DATE 9-16-41

TITLE

WING REPORT

SUBMITTED UNDER

Contract No. 557

PREPARED BY: CASWELL
BANKERD

GROUP: Stress

REFERENCE:

CHECKED BY: ZALLER
COLE

APPROVED BY: Clements

NO. OF PAGES

NO. OF DIAGRAMS

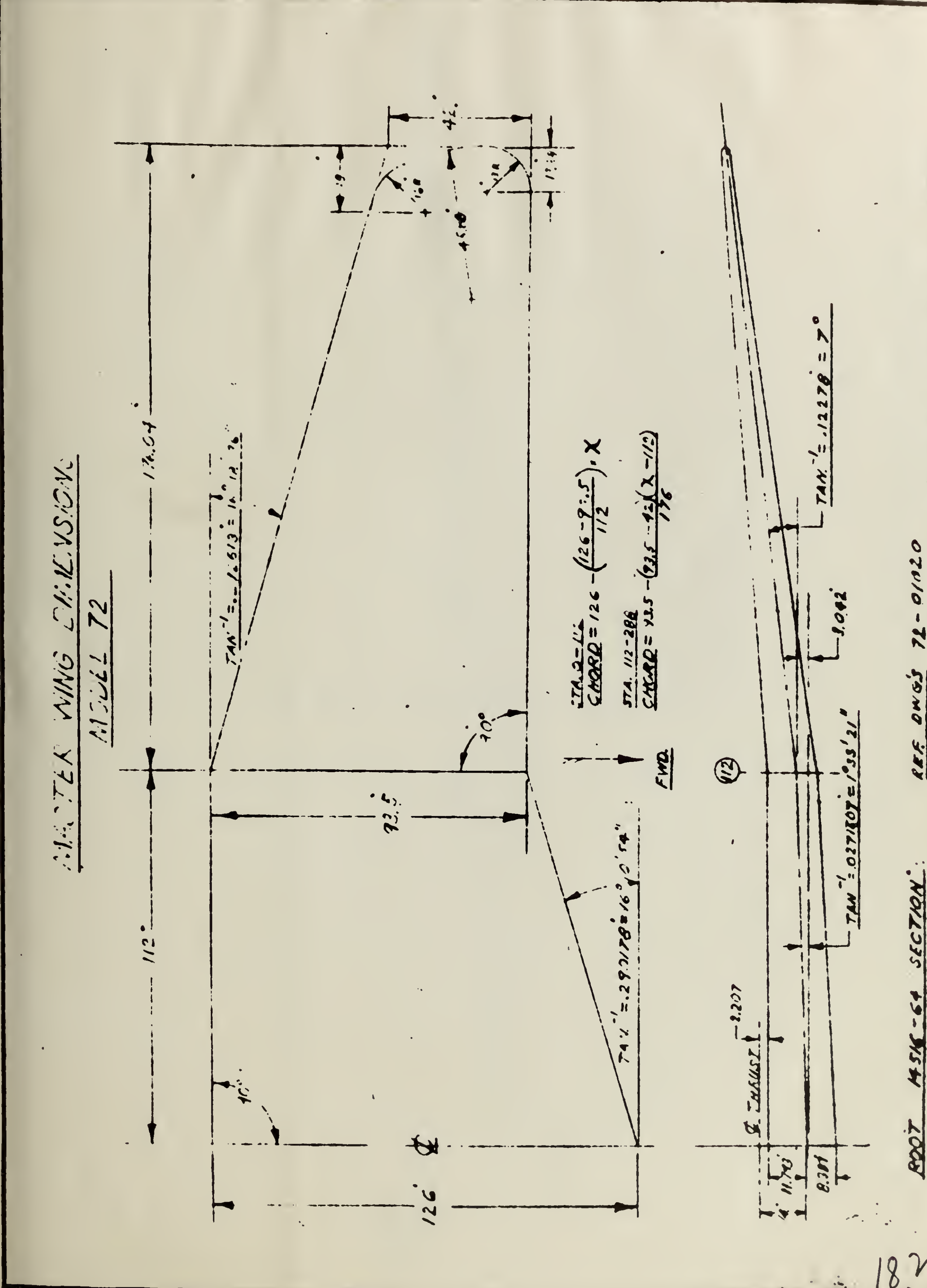
REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED

ANALYSIS
PREPARED BY
CHECKED BY
REVISED BY

VULTEE AIRCRAFT
DIVISION AVIATION MANUFACTURING CORP.

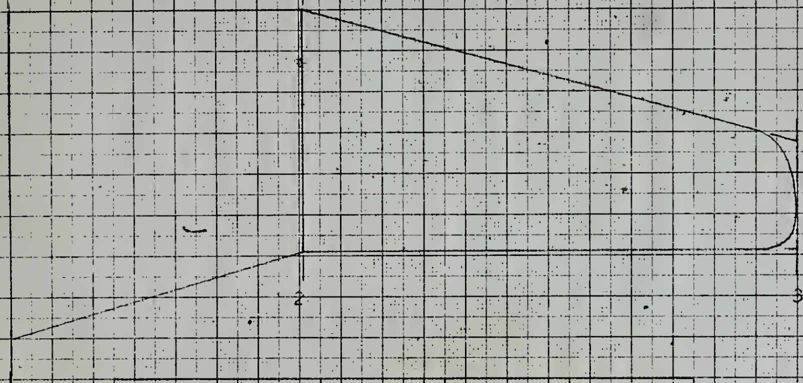
PAGE 3 12
REPORT NO. 1732
MODEL 72
DATE 1-25-41



DEFENDANTS' EXHIBIT L

VULTEE MODEL V72 (A35) "VENGEANCE" AIRPLANE

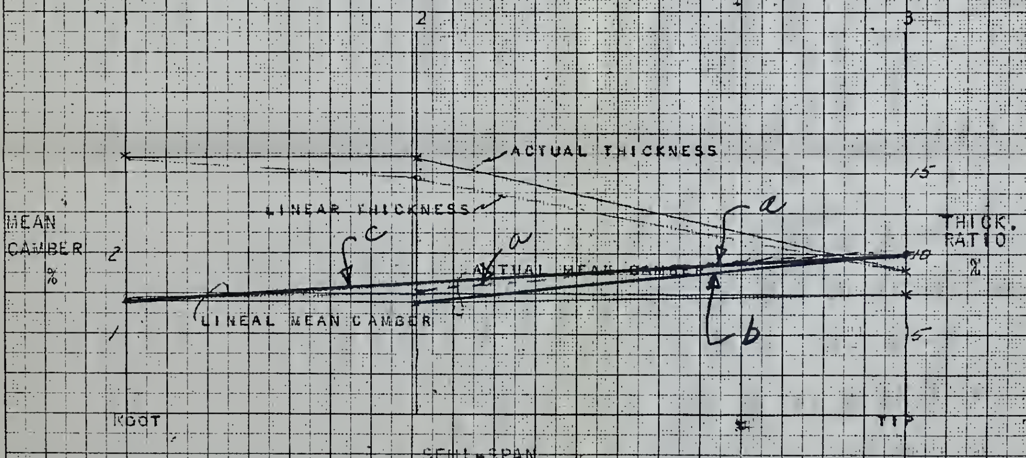
(REFER: DEF. EXH.



SECTION	1	2	3
PROFILE	14516-64	14516-64	20509-64
LOCATION % OF SEMI-SPAN	0	38.8	100
MEAN CAMBER % OF CHORD	1.4	1.4	2.0
THICKNESS RATIO % OF CHORD	16.0	16.0	9.0

LINEAR DISTRIBUTION

MEAN CAMBER % OF CHORD	1.4	1.5	2.0
THICKNESS RATIO % OF CHORD	16.0	14.8	9.0



Admitted November 24, 1950.

DEFENDANTS' EXHIBIT M

Contract No. DA-W 535 ac-46

Contract
(Supplies)
JKR:RC

ANMB Preference A-1-D

War Department
(Department)

The Glenn L. Martin Company
(Contractor)

Contract for 500 B-26B Medium Bombardment Airplanes and Spare Parts Therefor and Data.

Amount, $............

Place: Materiel Division, Air Corps, U. S. Army, Wright Field, Dayton, Ohio.

The Finance Officer, U. S. Army, Wright Field, Dayton, Ohio, is designated as the officer to make payments in accordance with this contract.

The supplies and services to be obtained by this instrument are authorized by, are for the purpose set forth in, and are chargeable to Procurement Authority AC 299 P 111-30 A 0021-13, the available balance of which is sufficient to cover cost of same.

AFP: 171981

Letters: June 4, 1941, and June 6, 1941.

Approval recommended: June 24, 1941, for the Chief of the Air Corps.

/s/ W. F. VOLANDT,
Colonel, Air Corps,
Asst. to Chief Mat. Div.

Defendants' Exhibit M—(Continued)

Approved: Jun 26, 1941. By direction of the Secretary of War under the provisions of Section 1(a) Act of July 2, 1940.

/s/ ROBERT P. PATTERSON,
Under Secretary of War.

In Witness Whereof, the parties hereto have executed this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA,

By /s/ G. V. McPIKE,
Major, A.C., Contracting Officer.

JOHN G. SALSMAN,
Major, A.C., U. S. Army,
Contracting Officer.
(Official title)

Two witnesses:

/s/ HARRY T. ROWLAND,
/s/ W. G. EAGER, JR.

[Seal] THE GLENN L. MARTIN COMPANY,
Contractor,

By /s/ J. T. HARTSON,
Vice Pres.,
Baltimore, Maryland.
(Business address)

I, ..., certify that I am the Secretary of the corporation named as contractor herein; that ...., who signed

Defendants' Exhibit M—(Continued)

this contract on behalf of the contractor, was then .... of said corporation; that said contract was duly signed for and in behalf of said corporation by authority of its governing body, and is within the scope of its corporate powers.

[Corporate Seal.]

I hereby certify that, to the best of my knowledge and belief, based upon observation and inquiry, J. T. Hartson, who signed this contract for the Glenn L. Martin Company, had authority to execute the same, and is the individual who signs similiar contracts on behalf of this corporation with the public generally.

/s/ G. V. McPIKE,
Major, Air Corps,
Contracting Officer.

Admitted November 24, 1950.

DEFENDANTS' EXHIBIT N

Contract No. W 535 ac-31733
(8851)

Contract
(Supplies)
WD:jmn

ANMB Preference A-1-A

Allocation Classification System Symbols: USA 1.00

War Department
(Department)

The Glenn L. Martin Company
(Contractor)

Contract for 900 B-26B1 Medium Bombardment Airplanes, Spare Parts and Data.

Defendants' Exhibit M—(Continued)

Amount, $. . . . .

Place: Army Air Forces, Materiel Center, Wright Field, Dayton, Ohio.

The Finance Officer, U. S. Army, Wright Field, Dayton, Ohio, is designated as the officer to make payments in accordance with this contract. The supplies and services to be obtained by this instrument are authorized by, are for the purpose set forth in, and are chargeable to the Procurement Authorities listed hereon, the available balances of which are sufficient to cover the cost of the same.

AC 2312 P 12-09 A 0705-23. . . . . . $. . . . .

AC 2382 P 82-09 A 0705-23. . . . . . $. . . . .

AFP: 216841 Class. 01-A AAF Stock No. 0121
01-K

This Formal Contract supersedes Letter Contract Special Form dated July 25, 1942.

Article 52

Approval.—This contract shall be subject to the written approval of the Secretary of War or such individual as said Secretary may designate and shall not be binding until so approved. The date of such approval shall be deemed to be the true date for the purpose of determining all times of performance.

Article 53

Alterations.—The following changes were made in this contract before it was signed by the parties hereto: Articles 15, 16, 16A, 17 to 53, inclusive, on pages 4a, 4a-1 to 4a-6, inclusive, 4b, 4b-1, 4c, 4d, 4d-1, 4e, 4e (cont'd), 4f to 4q, inclusive, and page 5, added as approved by the Director of the Bureau

Defendants' Exhibit M—(Continued)

of the Budget and/or the Under Secretary of War. Paragraph (d) to Article 19 added on page 4b-1. The designation "(a)" added before the title "Taxes" in Article 29, and paragraphs (b) and (c) added to Article 29 on pages 4d and 4d-1. The words "such date or dates . . . representative" in lines 7, 8 and 9 of Article 19 on page 4b hereof, deleted.

In Witness Whereof, the parties hereto have executed this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA,

By /s/ L. S. ROBINSON,
1st Lt., Air Corps,

JOSEPH E. DERHAM,
Lt. Col., Air Corps,
U. S. Army,
Contracting Officer.
(Official title)

THE GLENN L. MARTIN COMPANY,
Contractor,

By /s/ HARRY T. ROWLAND,
Vice President,
Baltimore, Maryland.
(Business address)

Two witnesses:

/s/ W. G. EAGER, JR.,
/s/ G. C. WILLIAMS.

Defendants' Exhibit M—(Continued)

I, M. G. Shook, certify that I am the Assistant Secretary of the corporation named as contractor herein; that Harry T. Rowland, who signed this contract on behalf of the contractor, was then Vice President of said corporation; that said contract was duly signed for and in behalf of said corporation by authority of its governing body, and is within the scope of its corporate powers.

[Corporate Seal]

/s/ M. G. SHOOK,
Ass't Sec'y

I hereby certify that, to the best of my knowledge and belief, based upon observation and inquiry, ..., who signed this contract for the ...., had authority to execute the same, and is the individual who signs similar contracts on behalf of this corporation with the public generally.

........................,
Contracting Officer.

W 535 ac-31733

Admitted November 24, 1950.

DEFENDANTS' EXHIBIT O

THE GLENN L. MARTIN CO.
BALTIMORE, MD.

MARTIN USA
TRADE MARK

PACKING ORDER

Packing Order 7505-90

DATE

No. 1-22492

DA W535 ac-46

YOUR ORDER

OUR ORDER S-0550

B/L No.

CAR No.

TO
Officer, G.F.E.
ield, Dayton, Ohio
DESTINATION UNKNOWN

R-45-14515-B.K.

R-11968

Billed from Accept Letter

() PILOT:-

QUAN.	PART NO.	DESCRIPTION	ATTACHING PARTS QUAN.	PART NO.	NAME	WEIGHT
	INSPECTED BY THE OFFICE OF THE A.A.F. RESIDENT REPRESENTATIVE C/O THE GLENN L. MARTIN COMPANY, BALTIMORE, MARYLAND					
e 16						
1	R-344000	Airplane, Martin Twin Engine Medium Bombardment Air Corps Model B-26-B35MA - Martin Model 179				

MARTIN NO 3778 A.C. NO. 41-32064 SERIAL NO. FB-909

In accordance with requirements of U.S. Air Corps Spec. C-213 dated January 25, 1939 and Amendment thereto and as amended by The Glenn L. Martin Company Specification #88B1, revised January 23, 1943, including Change Orders and Engineering Releases, as listed on Page Nos. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15 hereof and complete with Government Furnished Equipment.

Airplane completely setup, serviced and ready for flight at our field. Furnished and supplied all fuel, oil and cooling fluid necessary for engine tests, flight tests (to Spec. R-1880-D dated December 1, 1938) and amount required for fly-away as designated by ferry pilot. (Total number of engine fuel not to exceed 300 gallons).

960 GALLONS GASOLINE

"CERTIFIED IN ACCORDANCE WITH CONTRACT DA W535 ac-46, SPECIFICATION, DEVIATIONS AND CHANGE ORDERS PERTAINING THERETO AND TO INCORPORATE ALL ITEMS OF GOVERNMENT MATERIAL LISTED HEREON."

THE GLENN L. MARTIN CO. REPRESENTATIVE

Lawrence J. Kane
Chief Inspector

"I CERTIFY THAT I HAVE EXERCISED DUE DILIGENCE AND HAVE NO REASON TO BELIEVE THAT THE MATERIAL LISTED HEREON HAS NOT BEEN PROPERLY USED AS CERTIFIED BY THE CONTRACTOR."

Ira J. Grey
A. A. F. INSPECTOR, U.S. ARMY

DATE ACCEPTED: 7-17-43

Admitted November 24, 1950.

(S TO) ASSEMBLY
TION-ARMY-NAVY

SHEET NO. 1 OF ____ ISSUED BY Prod. Dept. ___ DATE June 9, 1943

WAR DEPT. AAF
FORM NO. 263A
APPROVED.........., 1943

Part 6

CONTRACTOR'S DELIVERY RECEIPT

DATE SEP 20 1944

AIRPLANE MODEL B26G-10-MA A. A. F. SERIAL NO. 43-34593 CONTRACT NO. W535 ac-31733 AC Spec. C-213

NAME OF CONTRACTOR .... MFR'S SERIAL NO. 8718 SPEC. NO. GLM Spec. No. 8881 dated January 1, 1943

I hereby certify that this airplane, at the time of delivery to the Ferry Pilot, was equipped with items as listed in preceding parts of this Form 263A, with the exceptions noted on Shortage List, Part 5.

(signed) ....
CONTRACTOR'S INSPECTOR

A. A. F. INSPECTOR-IN-CHARGE
(or authorized agent)

Mat. Comm. Eastern Procurement Dist.
Rank and Organization

(signed) Lt. Clement L. Curroy
A. A. F. RESIDENT REPRESENTATIVE
(or authorized agent)

Procurement Inspector
Official Designation

1 st. Lt. Air Corps
Rank and Organization

Operations Officer
Official Designation

DATE........................

I hereby certify that, to the best of my knowledge, no items of equipment, as delivered to me by the Contractor, have been removed from this airplane while in my custody, with the following exceptions:

....
(if none, so indicate)

....
SIGNATURE OF FERRY PILOT

Note: The Ferry Pilot is not required to make an actual check of the airplane for completeness.

....
Rank and Organization

....
Official Designation

RECEIPT FOR FERRY PILOT

MODIFICATION CENTER
or Other Station........................ DATE........................

Receipt is hereby acknowledged of Airplane Model........................

A.A.F. Ser. No........................

Delivered this date from........................
Name of Contractor

(signed)........................
Receiving Officer or Auth. Agent

....
Rank and Organization

Admitted November 24, 1950.

189

828

DEFENDANTS' EXHIBIT AA

CONTRACTOR'S COPY
NOT TO BE RETURNED

This is your official copy of the contract. The ORIGINAL contract only is signed by the parties. Signatures are not required on the contractor's copy.

SUPPLEMENTARY CONTRACT

FIXED PRICE CONTRACT

(SUPPLIES)

Contract No. a LL 76927

Negotiated Contract

NAVY DEPARTMENT
BUREAU OF SUPPLIES AND ACCOUNTS
(Department)

GLENN L. MARTIN COMPANY
(Contractor)

Contract for SEE INSIDE Amount, $

Place FOB CONTRACTOR'S PLANT BALTIMORE, MARYLAND

THIS CONTRACT, entered into this 11th day of July, 1942, by the UNITED STATES OF AMERICA, hereinafter called the Government, represented by the contracting officer executing this contract, and GLENN L. MARTIN COMPANY

a corporation organized and existing under the laws of the State of

a partnership consisting of

an individual trading as

of the city of BALTIMORE, in the State of MARYLAND

hereinafter called the contractor, witnesseth that the parties hereto do mutually agree as follows:

ARTICLE 1. Scope of this Contract.--The contractor shall furnish and deliver all of the supplies or services described in Schedule A attached hereto for the consideration stated opposite each item or each lot in Schedule A, in strict accordance with the specifications, schedules and drawings attached to or designated in Schedule A, all of which are made a part hereof. Deliveries and payment of the contract price shall be made as stated in Schedule A. The rights and obligations of the parties hereto shall be subject to the provisions contained in Articles 1 to 11 of this contract, inclusive, as well as the provisions of Schedule A. In the event of any inconsistency between the provisions of the said Articles and the provisions of Schedule A, the latter shall be deemed to control to the extent of such inconsistency.

ARTICLE 2. Changes.--Where the supplies to be furnished are to be specially manufactured in accordance with drawings and specifications, the contracting officer may at any time, by a written order, and without notice to the sureties, make changes in the drawings or specifications, except Federal Specifications. Changes as to shipment and packing of all supplies may also be made as above provided. If such changes cause an increase or decrease in the cost of performing this contract, or in the time required for its performance, an equitable adjustment shall be made and the contract shall be modified in writing accordingly. Any claim for adjustment under this article must be asserted within 10 days from the date the change is ordered: Provided, however, That the contracting officer, if he determines that the facts justify such action, may receive, consider and adjust any such claim asserted at any time prior to the date of final settlement of the contract. If the parties fail to agree upon the adjustment to be made the dispute shall be determined as provided in Article 9 hereof. But nothing provided in this article shall excuse the contractor from proceeding with the contract as changed.

ARTICLE 3. Extras.--Except as otherwise herein provided, no charge for extras will be allowed unless the same have been ordered in writing by the contracting officer and the price stated in such order.

ARTICLE 4. Responsibility for supplies tendered.--The contractor shall be responsible for the articles or materials covered by this contract until they are delivered at the designated point, but the contractor shall bear all risk on rejected articles or materials after notice of rejection. Where final inspection is at point of origin but delivery by contractor is at some other point, the contractor's responsibility shall continue until delivery is accomplished.

~~ARTICLE 5. Increase or decrease.--Unless otherwise specified, any variation in the quantities called for, not exceeding 10 percent, will be accepted as a compliance with the contract, when caused by conditions of loading, shipping, packing, or allowances in manufacturing processes, and payments shall be adjusted accordingly.~~

ARTICLE 6. Additional security.--Should any surety upon the bond for the performance of this contract become unacceptable to the Government, or if any such surety shall fail to furnish reports as to his financial condition from time to time as requested by the Government, the contractor must promptly furnish such additional security as may be required from time to time to protect the interests of the Government and of persons supplying labor or materials in the prosecution of the work contemplated by the contract.

ARTICLE 7. Officials not to benefit.--No Member of or Delegate to Congress or Resident Commissioner shall be admitted to any share or part of this contract or to any benefit that may arise therefrom, but this provision shall not be construed to extend to this contract if made with a corporation for its general benefit.

ARTICLE 8. Covenant against contingent fees.--The contractor warrants that he has not employed any person to solicit or secure this contract upon any agreement for a commission, percentage, brokerage, or contingent fee. Breach of this warranty shall give the Government the right to annul the contract, or, in its discretion, to deduct from the contract price or consideration the amount of such commission, percentage, brokerage, or contingent fees. This warranty shall not apply to commissions payable by contractors upon contracts or sales secured or made through bona fide established commercial or selling agencies maintained by the contractor for the purpose of securing business.

ARTICLE 9. Disputes.--Except as otherwise specifically provided in this contract, all disputes concerning questions of fact arising under this contract shall be decided by the contracting officer, subject to written appeal by the contractor within 30 days to the head of the department concerned or his duly authorized representative, whose decision shall be final and conclusive upon the parties hereto. In the meantime the contractor shall diligently proceed with performance.

ARTICLE 10. Race Discrimination.--The contractor, in performing the work required by this contract, shall not discriminate against any worker because of race, creed, color, or national origin. The contractor further agrees that each subcontract made under this contract will contain a similar provision with respect to non-discrimination.

ENTERED

APR 7 1943

any assistant head of the executive department involved, and the term "his duly authorized representative" shall mean any person authorized to act for him other than the contracting officer.

(b) The term "contracting officer" as used herein shall include the chief of the Bureau of Supplies and Accounts, the Purchasing Officers in such Bureau, and their duly appointed successors and duly authorized representatives.

IN WITNESS WHEREOF, the parties hereto have executed this contract as of the day and year first above written.

THE UNITED STATES OF AMERICA

By ______________________

Purchasing Officer,
Bureau of Supplies and Accounts,
Navy Department,
(Official title)

Two witnesses:

V. Seth

G. C. Williams

THE GLENN L MARTIN COMPANY
Contractor.

Harry T. Rowland, Vice President

Baltimore, Maryland
(Business address)

I, M. G. Shook, certify that I am the Asst. Secretary of the corporation named as contractor herein; that Mr. Rowland who signed this contract on behalf of the contractor, was then Vice Pres. of said corporation; that said contract was duly signed for and in behalf of said corporation by authority of its governing body, and is within the scope of its corporate powers.

M. G. Shook
Corporate Seal

I hereby certify that, to the best of my knowledge and belief, based upon observation and inquiry, ______, who signed this contract for the ______, had authority to execute the same, and is the individual who signs similar contracts on behalf of this corporation with the public generally.

____
Contracting Officer.

U.S. Standard Form No. 25 (Revised)
Approved by the Secretary
of the Treasury
Sept. 1[?], 1935

PERFORMANCE BOND
(Construction or Supply)
(As modified for use by the Navy Department)

NO BOND OR OTHER SECURITY REQUIRED

KNOW ALL MEN BY THESE PRESENTS, That we,

(See Instructions 4, 5 and 7)

as PRINCIPAL and as SURETY,

(See Instructions 2, 3, 4 and 7)

are held and firmly bound unto the United States of America, hereinafter called the Government, in the penal sum of dollars lawful money of the United States, for the payment of which sum well and truly to be made, we bind ourselves, our heirs, executors, administrators, and successors, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, That whereas the principal entered into a certain contract, hereto attached, with the Government, dated , 19

NOW, THEREFORE, If the principal shall well and truly perform and fulfill all the undertakings, covenants, terms, conditions, and agreements of said contract during the original term of said contract and any extensions thereof that may be granted by the Government, with or without notice to the surety, and during the life of any guaranty required under the contract, and shall also well and truly perform and fulfill all the undertakings, covenants, terms, conditions, and agreements of any and all duly authorized modifications of said contract that may hereafter be made, notice of which modifications to the surety being hereby waived, then, this obligation to be void; otherwise to remain in full force and virtue.

IN WITNESS WHEREOF, the above-bounden parties have executed this instrument under their several seals this day of , 19 , the name and corporate seal of each corporate party being hereto affixed and these presents duly signed by its undersigned representative, pursuant to authority of its governing body.

In presence of—

______________________ ______________________ SEAL
(Principal)

______________________ ______________________ SEAL
(Principal)

______________________ ______________________ SEAL
(Surety)

______________________ ______________________ SEAL
(Surety)

The rate of premium on this bond is ______________ per thousand.

Total amount of premium charged, $______________

(The above must be filled in by corporate surety)

If individual sureties sign the above bond the Affidavits and Certificates on the Appended Sheet must be executed.

337P

Admitted November 24, 1950.

831

DEFENDANTS' EXHIBIT BB

4/11/44

BALTIMORE, MD.

PACKING ORDER

Order Number 5403-93

No. 44001

YOUR ORDER C.76927

OUR ORDER S-1910

B/L No.

CAR No.

D TO Accepted by I.N.A. Baltimore, USN
For Delivery to: Supply Officer,
Naval Air Station, Norfolk, Virginia

AIR TO DESTINATION
(PILOT -)

QUAN.	PART No.	DESCRIPTION	ATTACHING PARTS QUAN.	ATTACHING PARTS PART No.	ATTACHING PARTS NAME	WEIGHT
		INSPECTED BY I.N.A. BALTIMORE				
1	162B100	Airplane, Class VPB, Model PBM-3, Martin No. 2908, Navy No. 6455				

Constructed in accordance with The Glenn L. Martin Company's Detail Specification No. SD-250-3-1A, and requirements of Bureau of Aeronautics Specification SD-250-3-1 dated 6 June 1940, and revisions thereto, complete with Government Furnished Equipment.

Airplane completely set up, ground tested and serviced with 1,000 gallons of gasoline (100 Octane) and 80 gallons of oil ready for flight at the Contractor's plant, after acceptance of airplane.

See Page No. 2 for record of Navy Changes pretaining to this airplane.

Due to delivery of airplane being made by Contractor [illegible] to a Naval Activity at Norfolk, Va. the signature [illegible] is a verification of material listed above [illegible] and is not a signature of acceptance.

Cleanliness & finish not according to delivery [illegible]
[illegible]

ALL STRAINERS CLEANED IN THIS AIRPLANE PRIOR TO DELIVERY.

THE SELF-SEALING FUEL CELLS IN THIS AIRPLANE HAVE NOT BEEN SLOSHED FOR USE WITH AROMATIC FUELS - TO BE TAKEN CARE OF LATER.

SIGNATURE J. G. Sieppel THE GLENN L. MARTIN CO. INSPECTOR

[illegible] BALTIMORE INSPECTOR OF NAVAL AIRCRAFT

192

(TO) ASSEMBLY- ...ION-ARMY-NAVY SHEET NO. 1 OF 3 ISSUED BY [illegible] DATE [illegible]

16,115-43

THE GLENN L. MARTIN CO.
BALTIMORE, MD.

PACKING ORDER

MARTIN USA
TRADE MARK

Packing Order No. 5403-93

DATE JAN 12 1944
NO. 1-81105
Suppl. Contr. NOs-LL76927
YOUR ORDER
GLM Suppl. No. 136D
OUR ORDER 5400 Series

...d by: I.N.A. Baltimore, USN
...y-Away Delivery R 44 37896
...to Destination (Pilot:

B/L No.
CAR No.

QUAN.	PART NO.	DESCRIPTION	ATTACHING PARTS QUAN.	PART NO.	NAME	WEIGHT
	42514 13186	INSPECTED BY I.N.A. BALTIMORE				
1	162D100	Airplane, Class VPB, Model PBM-3D				
		MARTIN NO. 7990 NAVY NO. 48219				
		This airplane furnished, completely assembled and ready for flight in accordance with The Glenn L. Martin Company Specification SD-250-3-1A dated June 26, 1941, as modified by the changes listed in Exhibit A of Contract (such Specification as so modified being herein after called Specification SD-250-3-1A) and complete with Government Furnished Equipment.				
17	1944	Airplane serviced with 700 gallons of gasoline (100 Octane), and 80 gallons of oil.				
		Auxiliary Bomb Bay Fuel Tanks to be forwarded under separated Notice of Shipment.				

ALL STRAINERS CLEANED IN THIS AIRPLANE PRIOR TO DELIVERY

SIGNATURES: J Deaton McDaniel — THE GLENN L. MARTIN CO. INSPECTOR

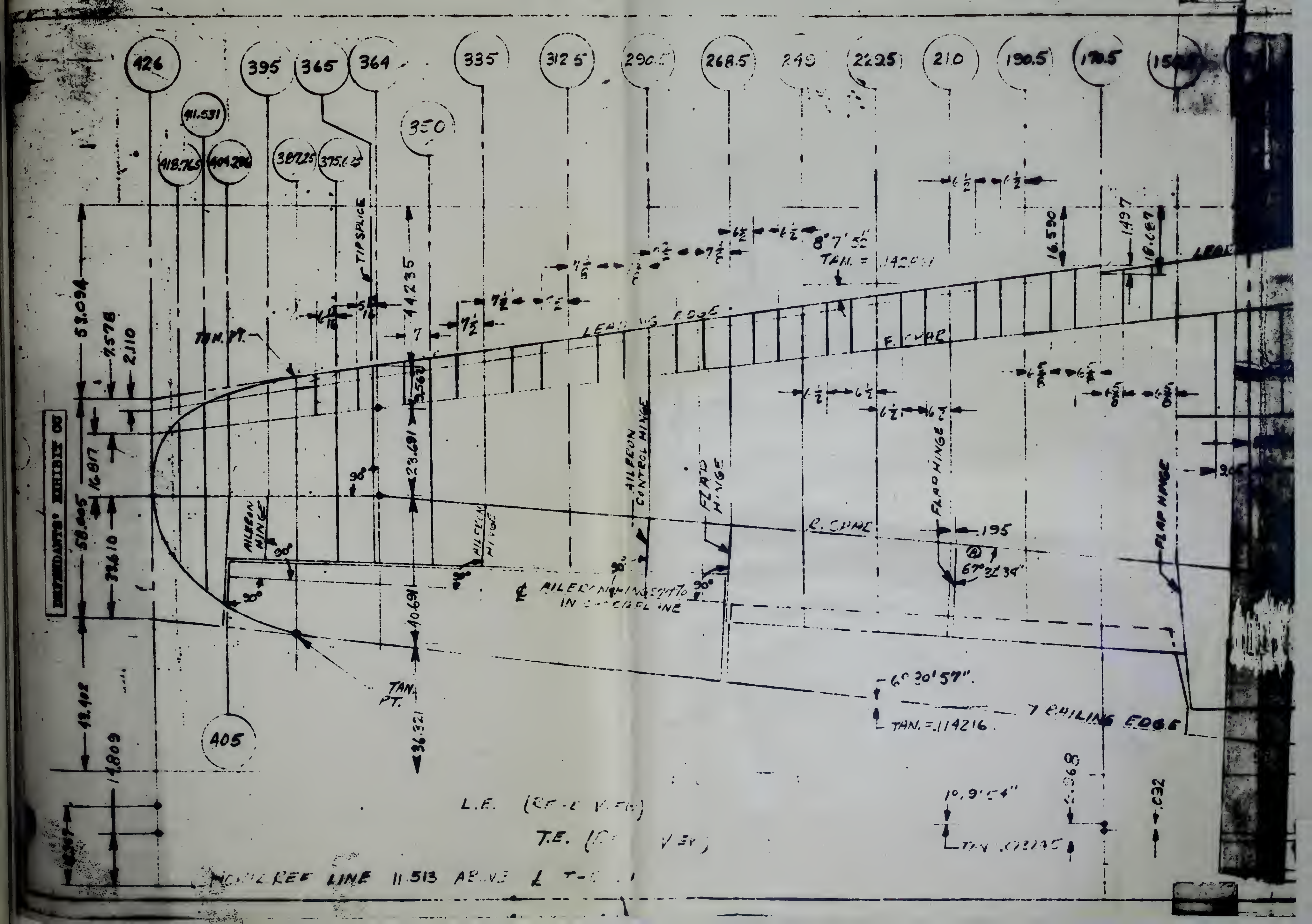
Victor E. Sage, by direction — BALTIMORE INSPECTOR OF NAVAL AIRCRAFT

ALL changes, additions and deletions are void unless signed by both GLMCO and INA.

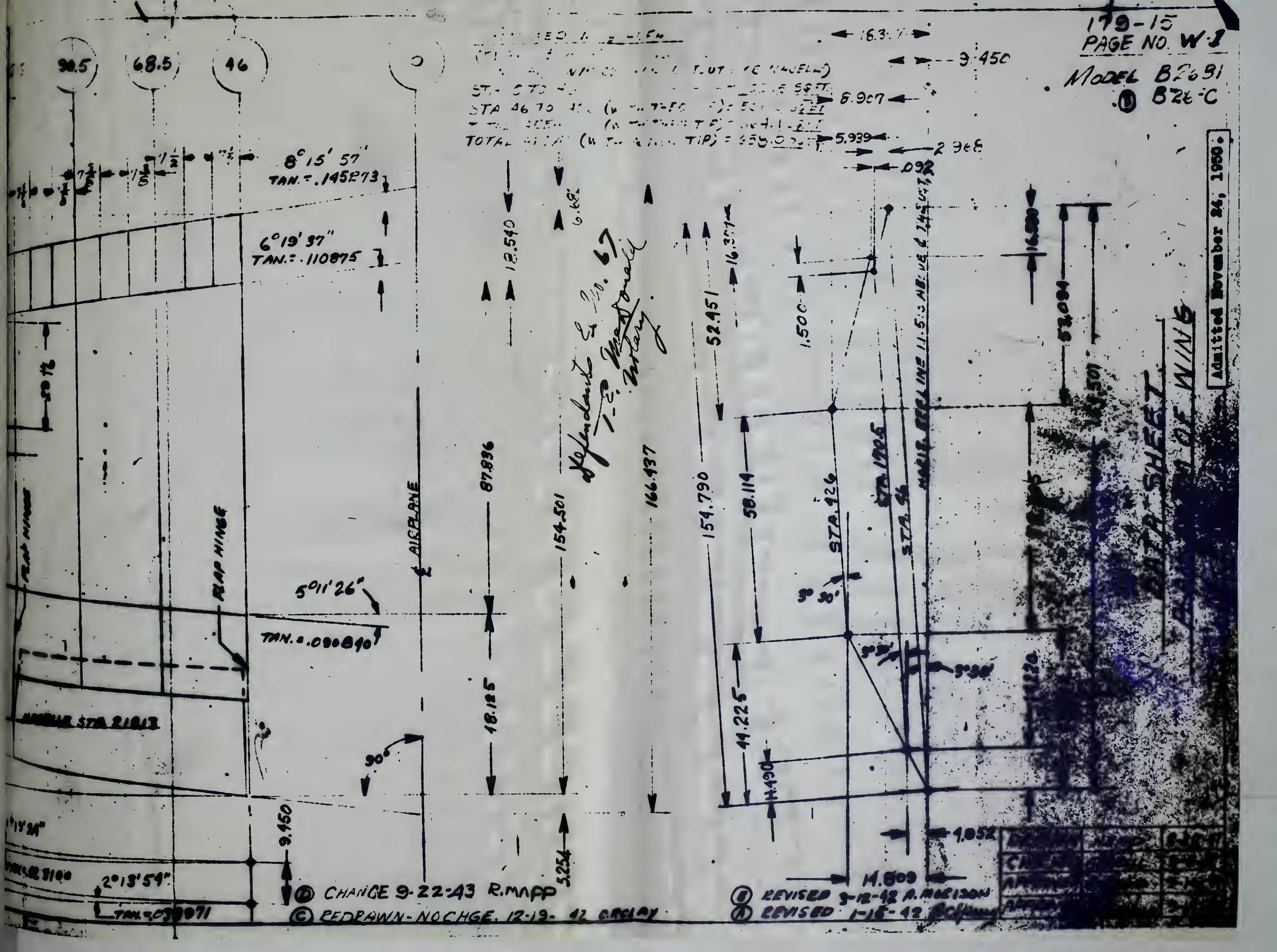
DATE ACCEPTED: 1/7/44 1010

Admitted November 24, 1950.

...TO) ASSEMBLY-...ION-ARMY-NAVY SHEET NO. 1 OF ____ ISSUED BY Prod. Dept. MH DATE



DEFENDANTS' EXHIBIT 00
426
395
365
364
335
312.5
268.5
222.5
210
190.5
170.5
411.531
418.765
404.296
387.25
375.625
350
405
TIPSPLICE
44.235
53.094
7.578
2.110
TAN. PT.
LEADING EDGE
F. CHORD
16.817
58.005
33.610
19.402
14.809
23.691
40.691
36.321
AILERON HINGE
AILERON CONTROL HINGE
FLAP HINGE
R. CHORD
.195
67° 32' 34"
8° 7' 52"
16.590
1.497
10.687
6° 30' 57"
TAN. = .114216
TRAILING EDGE
TAN. PT.
L.E.
T.E.
10° 9' 54"
.032
LINE 11.513



179-15
PAGE NO. W-8
MODEL B26 91
B26-C
Admitted November 24, 1950.
90.5
68.5
46
0
TOTAL
8°15' 57"
TAN. = .145273
6°19' 37"
TAN. = .110875
5°11' 26"
TAN. = .090840
2°13' 59"
FLAP HINGE
AIRPLANE
87.836
154.501
166.437
154.790
58.114
52.451
12.540
18.125
41.225
1.490
1.500
9.450
5.254
5.939
2.968
.092
8.907
16.377
4.809
1.052
STA. 126
STA. 56
3° 30'
Defendant's Ex. No. 67
I. E. MacDonald
Notary
CHANGE 9-22-43 R. MAPP
REDRAWN-NO CHGE. 12-19-42
REVISED